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**BEET SUGAR  
DEVELOPMENT FOUNDATION**

**SUGARBEET RESEARCH**

**1997 REPORT**





## FOREWARD

SUGARBEET RESEARCH is an annual compilation of progress reports concerning research by U. S. Department of Agriculture, Agricultural Research Service investigators and other cooperators who are engaged in sugarbeet research. The report was assembled and produced at the expense of the Beet Sugar Development Foundation, and is for the sole use of its members and the cooperators. Much of the data has not been sufficiently confirmed to justify general release and interpretations may be modified with additional experimentation. This report is not intended for publication and should not be used for cited reference nor quoted in publicity or advertising. Reproduction of any portion of the material contained herein will not be permitted without the specific consent of the contributor and the Beet Sugar Development Foundation

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# **SUGARBEET RESEARCH**

## **1997 REPORT**

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## ABSTRACTS OF PAPERS PUBLISHED OR APPROVED FOR PUBLICATION, 1997

DUFFUS, J.E. Beet Yellow Stunt. Compendium of Lettuce Diseases, Am. Phytopathol. Soc., pp. 37-38. 1997.

Beet yellow stunt virus (BYSV) is a potentially destructive yellows-type virus. It has been found in California and England. The virus is similar in many ways to beet yellows virus, but they are not serologically related. They also differ markedly in host range, especially in the family Asteraceae: BYSV infects sowthistle and lettuce, which are immune to beet yellows virus.

The disease has been observed since the early 1960s in California and has caused only minor damage in most years. In a few seasons the disease caused major losses in individual fields.

The disease symptoms are quite distinct and can be readily recognized in the field. Initial symptoms are yellowing of the older leaves, similar to the early symptoms induced by beet western yellows virus. As growth progresses, the older leaves of affected plants show pronounced yellowing, and the plants collapse prematurely and die. Growers refer to the disease as "drop, without the fungus" because of the similarity of the collapse symptoms to *Sclerotinia* spp. The disease may be rapidly diagnosed in the field by pulling affected plants and cutting the stem and crown tissue longitudinally. The phloem tissue in BYSV-infected plants is extremely necrotic and shows distinct brown zones extending into the crown tissue.

BYSV particles are long, flexuous, filamentous rods approximately 1400 nm long and 12.5 nm in diameter. The virions have a single major capsid protein with a molecular weight of approximately 24,500 and a single species of single-stranded RNA of approximately 18,000 nucleotides. BYSV is a closterovirus that is not serologically related to beet yellows virus or citrus tristeza virus but is similar to them. The host range of the virus includes plants in the families Chenopodiaceae, Asteraceae, Geraniaceae, Portulacaceae, and Solanaceae.

BYSV is transmitted by aphids in a semipersistent manner. The sowthistle aphid, *Hyperomyzus lactucae* (L.), the most efficient vector, is commonly found on sowthistle, *Sonchus oleraceus* L., but feeds only transiently on lettuce and rarely on sugarbeet. The virus is transmitted less efficiently by the green peach aphid, *Myzus persicae* (Sulzer), and by the potato aphid, *Macrosiphum euphorbiae* (Thos.). Most aphids cease to transmit the virus one or two days after acquisition, but a few transmit for up to four days. BYSV is not transmitted by insects after molting.

Because sowthistle is the principal source of the virus and the only rearing host of the sowthistle aphid, the disease is unlikely to reach serious proportions except where large concentrations of sowthistle are present. Wild lettuce, *Lactuca serriola* L., is also

commonly infected. No evidence has been found that the virus is seedborne.

The distribution of BYSV in wild *Sonchus* spp. in California is so extensive that elimination of the virus is not possible. New plantings of susceptible crops, however, should be isolated from large areas of weeds.

DUFFUS, J.E. Beet Western Yellows. Compendium of Lettuce Diseases, Am. Phytopathol. Soc., pp. 36-37. 1997.

Beet western yellows virus (BWYV) has been associated with lettuce production since at least the 1950s, when it and the complex of virus diseases affecting spring crops of lettuce were referred to as "June Yellows." BWYV is responsible for yield and quality losses of lettuce throughout the world.

Many variants of the virus have been distinguished on the basis of host range and virulence. Different strains may induce similar reactions in some plant species and distinct reactions in others with regard to susceptibility, stunting, and yellowing.

Symptom response varies with cultivar, plant maturity and climatic conditions. Plants show initial symptoms 12-30 days after inoculation by aphids. Yellowing develops in older and middle-aged leaves as a mild chlorotic spotting of interveinal areas, most often at the leaf tips. As the disease progresses, the yellowing becomes more intense, and more of the interveinal tissue turns yellow. Older infected leaves become thickened, brittle, and almost completely yellow except for green areas adjacent to the veins. The symptoms closely resemble those associated with magnesium deficiency.

BWYV induces internal rib necrosis in the crisphead cultivar Climax, in association with lettuce mosaic virus.

BWYV is a member of the luteovirus group, an extremely important group of viruses affecting most of the world's major crops. BWYV particles are small, simple isometric virions with icosahedral symmetry, a diameter of about 25 nm, and a sedimentation coefficient of 115-118S. Most isolates contain a single component of single-stranded RNA of approximately 5,600 nucleotides. The virions contain two capsid proteins of approximately 22,000 and 52,000 molecular weight. BWYV isolates are serologically related to other luteoviruses.

The host range of BWYV is very broad; over 146 species in 23 families are susceptible to various isolates. Different variants seem to predominate in different plant species and may have distinctive host ranges. Diagnostic species include *Capsella bursa-pastoris* (L.) Medik., *Senecio vulgaris* L., and *Montia perfoliata* (Donn. ex Willd.).

Of the eight or more species of aphids that transmit BWYV, the most important vector is *Myzus persicae* (Sulzer), the green peach aphid. Transmission is in a persistent (circulative) manner, with the virus persisting in vectors for over 50 days. Vectors retain



the ability to transmit the virus after molting but do not transmit it to their progeny. The minimum acquisition feeding period is 5 min, and the minimum inoculation feeding period is 10 min. The latent period is 12-24 hr.

Virus spread of BWYV is much more general and widespread than the distribution of nonpersistent or semipersistent viruses, which is often on the margins of fields. Virus sources are abundant among common crop plants, including sugarbeet, broccoli, cauliflower, radish, horsebean, spinach, lettuce, pea, and potato. Weed hosts that are commonly infected include wild crucifers (mustard, radish, and rocket), cheeseweed, fiddleneck, and wild species of the Asteraceae.

BWYV is extremely difficult to control through the elimination of virus sources because of its extensive host range of crops and weeds. However, new plantings should be separated from infected crops by as much space and time as possible.

Crisphead lettuce varieties have a much higher tolerance to BWYV than certain romaine and butterhead varieties. Resistance to BWYV in butterhead cultivars appears to be associated with a single recessive gene.

DUFFUS, J.E. Sowthistle Yellow Vein. Compendium of Lettuce Diseases, Am. Phytopathol. Soc., pp. 46-47. 1997.

Sowthistle yellow vein virus (SYVV) has been associated with lettuce production in California and Arizona since the early 1960s. The virus is common in sowthistle (*Sonchus oleraceus* L.), where it induces a striking vein-clearing-vein-banding symptom.

Symptoms in lettuce are characterized by vein-clearing and vein-banding, especially at the tips of affected leaves. These symptoms resemble those produced by the lettuce big-vein, but SYVV-affected leaves assume a truncated form. Leaf tips are squared off and show a distinctly closer or compressed vein formation. In plants affected with big-vein, leaves may attain normal size and margins show a pronounced ruffling. SYVV-infected plants may become severely stunted and are often unsuitable for market.

Particles of SYVV are bacilliform (about 230 nm long and 100 nm wide) and are in the plant rhabdovirus group. The virus resembles Sonchus yellow net virus and lettuce necrotic yellows but may be distinguished from these viruses by lack of mechanical transmissibility. It was the first virus to be shown to multiply in its aphid vector as well as its plant hosts.

SYVV is transmitted by the sowthistle aphid, *Hyperomyzus lactucae* (L.), in a persistent-propagative manner. It is retained by the vector for over 50 days. Sowthistle is the principal source of the virus and the only rearing host of *H. lactucae*.

Sowthistle is commonly infected with SYVV throughout the year. The virus is more damaging when lettuce is grown in close proximity to infected sowthistle stands occurring

on abandoned properties or as uncontrolled weeds in crops.

The virus is maintained in wild *Sonchus*. Destruction of weed patches in waste areas and in fields can eliminate the virus reservoir. New plantings should be isolated from large areas of weeds.

DUFFUS, J.E. Sonchus Yellow Net. Compendium of Lettuce Diseases, Am. Phytopathol. Soc., p. 46. 1997.

Sonchus yellow net virus (SYNV) is a rhabdovirus that is similar to sowthistle yellow vein virus (SYVV) but differing in host range, aphid vectors, serology and mechanical transmissibility. It has been found only in Florida in crisphead and romaine lettuce and in weeds of the Asteraceae family, including *Bidens pilosa* L., *Senecio glabellus* Poir., and *Sonchus* spp.

Symptoms on lettuce include light veinclearing, general leaf yellowing, and severe plant stunting, followed by some recovery. A bright yellow interveinal spotting on older leaves is characteristic. In sowthistle, distinct local lesions follow mechanical inoculation. Veinclearing appears a few days later, followed by the occurrence of yellow patches between the veins. Eventually the whole leaf turns yellow. In advanced stages, some of the yellowed areas turn brown.

The morphology of SYNV particles is similar to that of SYVV particles in size, structure, and protein composition. However, the two viruses are serologically distinct and differ in their mechanical transmissibility and aphid vectors. SYVV is transmitted in a persistent manner by *Aphis coreopsidis* (Thomas), which colonizes *B. pilosa*, but is not transmitted by either *Hyperomyzus Lactucae* (L.) or *Dactynotus* spp., which colonize *Sonchus*. All hosts infected in nature, except lettuce, have also been infected with Bidens mottle virus.

SYNV occurs naturally in *B. pilosa*, a common weed in Florida, in combination with Bidens mottle virus. However, it has been found in only a few lettuce plants showing bright yellow spotting symptoms. On the basis of the low natural incidence of SYNV, it does not appear to be an immediate threat to Florida lettuce.

Eliminating weeds of the Asteraceae, including *Bidens*, *Sonchus* spp., and *Senecio* spp., the only naturally occurring hosts, near lettuce plantings would be an effective control.

DUFFUS, J.E. and G.C. WISLER. Lettuce Chlorosis. Compendium of Lettuce Diseases, Am. Phytopathol. Soc., p. 42. 1997.

A whitefly-transmitted virus termed lettuce chlorosis virus (LCV) was separated from the yellowing complexes in the southwest desert of the United States in 1991. The virus is similar to lettuce infectious yellows virus (LIYV) in symptomology on lettuce but is readily distinguished by serology, dsRNA analysis, host range, and insect-vector

relationships. The virus has been found in the Imperial and Palo Verde Valleys of California and in the Yuma area of Arizona.

LCV induces severe yellowing and/or reddening and stunting, rolling, vein-clearing, and brittleness of leaves in lettuce and a wide range of weed and crop species. Symptoms in lettuce are virtually identical to those induced by LIYV.

LCV particles are long, flexuous, filamentous rods with a typical length of 800-850 nm and 12 nm in width. The viral ssRNA consists of about 8,000 nucleotides, and the dsRNA has a corresponding relative electrophoretic mobility in agarose gels. In Western blot analysis, the coat protein has a molecular weight of about 32 kDa. Despite the similarities between LCV and LIYV, including similar particle lengths and the production of cytoplasmic vesicles, the two viruses are serologically distinct. No cross-reactivity has been observed in reciprocal enzyme-linked immunosorbent assay (ELISA) tests or Western blot analyses.

LCV has a wide host range of at least 27 plant species in 12 families. However, it does not infect plants in the Cucurbitaceae, a major difference from the host range and epidemiology of LIYV.

LCV is transmitted by the whiteflies *Bemisia tabaci* (Gennadius) and *B. argentifolii* Bellows & Perring with about the same efficiency. This is a major difference between LCV and LIYV since LIYV is transmitted very inefficiently by *B. argentifolii*. LCV is transmitted by *Bemisia* in a semipersistent manner but is retained for a longer period of time than LIYV (four days for LCV, three days for LIYV).

Fall-planted melons were the major source of LIYV for infection of fall vegetable crops in the Imperial Valley of California. Currently, relatively few acres of cucurbit crops are planted in the fall in the southern California desert because of the destructive effects of high populations of *B. argentifolii*, and the incidence of LIYV has dropped to insignificant levels. Cucurbits are not a host of LCV; thus, the incidence of LCV has not been affected by this major cropping change. It appears that weed hosts are the major source of LCV. Unless other susceptible crops are planted during the late summer planting period in the desert, the incidence of LCV should remain low.

✓ A reduction of whitefly populations and attempts to eliminate weed sources of the virus would aid in the reduction of LCV incidence.

DUFFUS, J.E. Turnip Mosaic. Compendium of Lettuce Diseases, Am. Phytopathol. Soc., pp. 50-51. 1997.

Turnip mosaic virus (TuMV) is world-wide in distribution and is frequently reported in temperate regions of Africa, Asia, Europe, and North America. It was first associated with lettuce in 1966, when it was observed in the Salinas Valley of California. TuMV susceptibility in lettuce is restricted to crisphead lettuce types with downy mildew resistant

progenies derived from P.I. 91532.

Early symptoms on susceptible lettuce cultivars consist of numerous, small, light green, circular to irregular lesions distributed at random between and adjacent to the veins. Infection is often accompanied by curvature of the midrib and asymmetrical distortion of the leaf blade. On seedling lettuce, the numerous chlorotic lesions nearly replace the normal dark green tissue, imparting a distinctly chlorotic color and a coarse mottle. The virus causes severe stunting of young lettuce and is occasionally lethal. During the reproductive phase of lettuce growth, necrotic lesions may develop on the seed stalk. Necrotic areas may form on the developing involucre bracts and peduncles, and many of the floral heads wither before they mature. Both numbers of seed per flower head and seed production per plant are extremely low.

The disease is readily distinguished from lettuce mosaic by the presence of numerous circular to irregular lesions, by the absence of a downward roll of the leaf tips, and by the dull yellow color of plants infected by lettuce mosaic.

The virus causes mottling and black necrotic spots in cabbage, cauliflower, and Brussels sprouts; mosaic with leaf distortion and stunting in turnip, swede (rutabaga), radish, rape, mustard, Chinese cabbage, watercress, and horseradish; and flower breaks in wallflowers, stock, zinnia, petunia, and anemone.

TuMV is a potyvirus with filamentous particles approximately 720 nm in length. The genome is a single strand of RNA. TuMV induces cylindrical and fibrous inclusions in the cytoplasm of infected cells. It is transmitted by many aphid species in a nonpersistent manner. TuMV is not serologically related to LMV and, unlike LMV, is not seed-transmitted.

TuMV has a very wide host range in 20 dicotyledonous families and is transmitted by over 40 aphid species. For these reasons, TuMV is likely to occur wherever susceptible lettuce cultivars are planted. Susceptible cultivars include Calmar, E-4, Imperial 410, Imperial Triumph, Valrio, Valtemp, Valverde, and potentially other cultivars with these lines or *Lactuca serriola* L. (P.I. 91532) in their genetic background. If abundant aphid and virus sources are present, the disease can spread rapidly through lettuce fields.

Three types of resistance to TuMV occur in lettuce: extreme resistance or immunity, tolerance or milder symptom expression, and resistance to infection by both aphids and mechanical inoculation. Planting TuMV-resistant lettuce types such as butterhead, leaf, or romaine or resistant crisphead varieties such as Climax, Great Lakes, Merit, or Vanguard is the most effective control measure. The crisphead variety Avoncrisp, leaf types Red Salad Bowl and Salad Trim, romaine type Valmaine, and a number of butterhead varieties are resistant to both TuMV and downy mildew. If susceptible cultivars are planted, destruction of weed patches in waste areas and fields is important. New plantings of susceptible cultivars should be isolated from large areas of weeds.



LEWELLEN, R.T. Nonbolting Tendency In Sugar Beet, A Continuing Plant Breeding Objective. California Beet Growers Assoc., 1997 Annual Report, pp. 27-29. 1998.

Breeding for resistance to bolting (nonbolting tendency) was one of the first objectives in setting up a breeding program for California. Bolting resistance is one of the main criteria that separates varieties grown in California from those grown in all other sugar beet production areas in North America. Although considered routine, a plant breeding program with varieties destined for California must include this as an ongoing objective. The coastal climate of California, on average, is ideal for evaluating and breeding for nonbolting tendency. Not only has the USDA at Salinas used the Central Coast area, but the famous "NB" varieties of Spreckels Sugar were developed by Dr. James Schulke in this environment. Betaseed also used trials in this area for their nonbolting work.

Primarily, bolting induction in the winter is a function of temperature and duration. For vernalization or thermal induction, the optimum temperature is 40-42(F. Below 36( the metabolic activity of the sugar beet plant is so low that induction occurs. In some instances, high temperatures, such as those in the late spring and summer in the Imperial Valley and Central Valley, are thought to revert thermal induction and the capacity of the plant to bolt is stopped or retarded.

Secondly, vernalization or chilling (as in fruit trees) is accumulative. The duration or accumulation of chilling needed to induce a sugar beet plant to bolt is dependent upon its genotype for bolting tendency. Typically, an easy bolting variety, such as those grown outside of California, requires only a few hundred to a 1000 hours of induction. I have estimated that a hard bolting variety such as SS-NB3 requires at least 2500 hours of induction. Of course, there is a range of varieties everywhere in between in their nonbolting tendency and requirement for induction. In seed production by the breeder or the seedsman, these requirements are known or quickly learned. My colleagues at Fort Collins, Colorado, for example, induce their breeding material in a cold room held at 42(F for four to six weeks. In my program at Salinas, to assure complete participation of all plants in seed production, plants are held for at least 16 weeks (2700 hours) in the cold room. For commercial sugar beet seed production, the easy bolting varieties were at one time grown near Phoenix, Arizona. However, as the nonbolting tendency of varieties for California and elsewhere increased, seed could not be produced in Arizona or Southern California (e.g. Hemet), and the beet seed industry was moved to western Oregon. On average, if a winter day in Oregon has 16 hours with temperatures favorable for thermal induction, up to 180 days may be required to achieve complete bolting.

There are other factors that influence bolting as well. For example, faster growing plants induce better than slower growing plants. Anything that influences growth rate appears to affect bolting. For instance, diseases usually reduce bolting rate, as do stresses of all kinds. High nitrogen fertility usually increases bolting rate, whereas low fertility reduces it. Inbreeding usually reduces it so that inbred parental lines, per se, often appear to be more bolting resistant than found for their hybrids.

Seed stalk initiation and growth also eventually require long days (long photoperiod due

either to greater than 12 hours of daylight or to supplemental lighting as in our greenhouses and growth chambers). Thus, in sugar beet, initiation of bolting is often called "photo-thermal induction."

And, of course, there are genetic effects and differences. The simplest of these is conditioned by the major gene *B*. Genotypes *bb* are biennial and require photo-thermal induction. Genotypes *BB* and *Bb* are annual and require only long days. Commercial sugar beet is of course biennial (*bb*). Most wild and weed beets (e.g., the weed beets of Imperial Valley and San Francisco Bay areas) are annual and have very short generation times. A second major gene that influences bolting tendency is *Lb* for late bolting. In otherwise isogenic backgrounds, *lblb* beets bolt later than *LbLb/Lblb* beets. This gene is of most concern to seedsmen when making hybrids between parental lines in Oregon. By chance, if the two parental lines differ in this gene, there is a problem getting good matching between lines during flowering and anthesis, and seed yield and quality may suffer.

The most important genetic aspects of bolting tendency, however, involve quantitative inheritance, meaning that the interaction of many genes, each with small effects, is required. Some of these genes appear to modify thermal induction and others appear to modify photo induction. Hard bolting lines or hybrids would have combinations of these genes (more accurately, alleles of these genes) that require greater photo-thermal induction. The purpose of our bolting evaluation and nonbolting selection trials is to identify these favorable combinations and to eliminate the genes or combinations that lead to easier bolting.

Where breeding and evaluation for bolting tendency are done is also significant. Because part of bolting induction requires long days, it is an advantage for the nonbolting hybrids of California to be produced in Oregon where the May-June photoperiod is hours longer and greater photo induction occurs. This difference is even greater between California and Northern Europe where summer days are very long. It is often observed that nonbolting varieties from California are not bolting resistant in Northern Europe, but that Northern European nonbolting varieties are usually nonbolting in California. The end result is that breeders have been able to develop varieties for California that are fall and winter planted that do not bolt, and photosynthate is stored as sugar rather than as seed.

Is bolting always bad? In the case of seed production and cross breeding, it is absolutely essential so that the seedsman and plant breeder can predictably and uniformly manipulate the crop. There is usually an ongoing balance between the level of bolting resistance acceptable for overwintered sugar beet production and the level that can be tolerated by the seedsman.

There is a possible (hypothetical) situation in sugar beet production where uniform and complete bolting might be desirable. In the Central Valley when sugar beet is planted in May of one year and harvested in May of the second year, most plants, even of nonbolting varieties, bolt. Because most of the growth and sugar accumulation has already been achieved and because the days are long with high levels of solar radiation, bolting does not

appear to decrease sucrose concentration or yield. Only after flowering and anthesis when seed is being set does there seem to be detrimental effects of reduced yield and increased fiber. In fact, at least in the early stages of bolting under these spring conditions, industry personnel have often noted that factory extraction is significantly improved. For instance, Elmer Bonetti of Union Sugar used to tell me that when a single variety, e.g. US H9, US H10, or US H11 was grown in Imperial Valley, Salinas Valley, and Los Banos area, sugar extraction at Betteravia changed from about 84 to 86 to 88 percent, respectively. He suggested that, in part, the higher extraction rate for Los Banos beets was due to bolting. Ed Swift of the old American Crystal Sugar factory at Clarksburg said that, consistently, spring beets in the early stages of bolting had the best extraction, and that if bolting could be controlled, it would be a useful trait in sugar beet production and processing. What is thought to account for this is that the ions and compounds (impurities) e.g. K, Na,  $\alpha$ -amino nitrogen, etc., accumulated in the storage root along with sugar are dramatically used or translocated into the rapidly growing seed stalk, significantly improving juice purity. Simultaneously, because of the high solar radiation, this growth is not at the expense of stored sugar.

Maybe teams of scientists including agronomists, plant breeders, geneticists, plant physiologists, molecular biologists, etc., need to determine what processes control bolting, both to inhibit bolting when it is undesirable and to promote it when it is. I think we can visualize potential plant growth regulators or hormones that could do this; there would be a treatment that would uniformly promote bolting and flowering to aid plant breeding and seed production programs and maybe a few weeks before harvest, to improve juice purity. Plant breeders for many years have used GA-3 (gibberellic acid) to aid bolting and reduce generation time. There are research programs in Europe on the molecular biology of sugar beet bolting. Much more advanced than these are research programs in the USA on other plant species (e.g. *Arabidopsis* - a test plant used by scientists because of its rapid life cycle) to understand and unravel the cascade of genetic, molecular, and physiological events that control bolting and flowering.

Nonbolting tendency or bolting resistance was one of the first objectives in sugar beet breeding in California. Given sufficient time and resources and an appropriate location, it is one of the most amenable to plant breeding. But like so many of the old traits, the need for breeding for bolting resistance does not appear.

LEWELLEN, R.T. Registration of Sugarbeet Germplasm Lines C78,C80, and C82. Crop Sci. 37:1037. 1997.

Sugarbeet (*Beta vulgaris* L.) germplasm lines C78(Reg. no. GP-182, PI 593671), C80 (Reg. No. GP-183, PI 593672), and C82 (Reg. No. GP-184, PI 593675) were developed by the USDA-ARS in cooperation with the Beet Sugar Development Foundation and the California Beet Growers Association. These lines are diploid ( $2x = 18$ ), multigerm, self-sterile, and segregate for hypocotyl color. They combine multiple disease resistance and segregate for resistance to rhizomania (*Rz*), caused by beet necrotic yellow vein primary base populations that have been developed in the virus yellows and multiple disease

resistance program in Salinas, CA. C78, C80, and C82 were released in 1994. With line improvement and progeny evaluation procedures, it should be feasible to extract parental lines from this material relatively quickly to obtain various combinations of disease and bolting and traits for productivity.

C78 is genetically similar to C46 except that it has resistance to rhizomania. It was developed using C46/2 as the BC<sub>1</sub> through BC<sub>3</sub> recurrent parent. C37 was used to make the F<sub>1</sub> in a cross to a Holly Hybrid Rz source. Following BC<sub>3</sub>, the line was increased five times. For three of these increases, recurrent phenotypic selections were made for resistance to rhizomania, including one cycle of selection for combined resistance to rhizomania, virus yellows [caused by beet western yellows virus (BWYV) and by beet yellows virus (BYV)], erwinia root rot, and powdery mildew. The final cycle of selection was for resistance to bolting. Nonbolted plants were selected from 12-mo-old plants in an overwintered planting. Within these nonbolted plants, a reselection was made based on individual root sucrose concentration. C78 has been evaluated as breeding lines similar to R678, R578, R478NB, R378, R278, and R278Y.

C80 is similar to C54, a broad-based population released in 1988, but will segregate for resistance to rhizomania. C54 was developed as line Y54 in the multiple disease resistance programs. It was derived from composite crosses among six breeding lines that collectively comprised germplasm from C37, 45%, C663, 32%, and C01, 23%. Except for the choice of C54 as the recurrent parent, C80 was developed similarly to C78 but underwent a different selection procedure for the last two cycles of selection. After two cycles of recurrent phenotypic selection for resistance to rhizomania, half-sib families were generated. Ninety-six families were tested at Salinas in trials grown under nondiseased, virus yellows, erwinia-powdery mildew infected, rhizomania, and bolting conditions. Based on yield, disease, and bolting data, eight families were selected, increased, and topcrossed onto a common monogerm tester and evaluated for hybrid performance. The second synthesis of each of these eight half-sib families was planted into a field infested with rhizomania and, at about 3 mo of age, was inoculated with *E. carotovora*. At 7 mo, mother roots within five of the families were selected based on sugar concentration. These roots were intercrossed in a seed increase plot to produce C80. C80 has been evaluated as breeding lines R680-#, R580-#, and R480-#.

C82 is a selection and recombination of lines similar to C76-43 and C76-89 released in 1993. Following three backcrosses of rhizomania resistance into C31/6, an advanced line from C31, line R76 was developed. The third-cycle synthesis of R76 selected for resistance to rhizomania was crossed to C31-43 and C31-89 to produce breeding lines R76-43 (C76-43) and R76-89 (C76-89). These two lines were grown in an overwintered nursery, to evaluate and select for nonbolting tendency. Nonbolted mother roots (12 mo old) were selected from each line and then reselected for high sucrose concentration. These mother roots were intercrossed in an isolated seed increase to produce C82. C82 is being evaluated as line R482NB and is similar in performance to breeding lines tested as R681, R581, and R484.

LEWELLEN, R.T. Registration of 11 Sugarbeet Germplasm C79 Lines with Resistance to rhizomania. Crop Sci. 37:1026. 1997.

Sugarbeet (*Beta vulgaris* L.) germplasm lines C79-1 through C79-11 (Reg. no. GP-171 to GP-181, PI 593660 to PI 593670) were developed by the USDA-ARS in cooperation with the Beet Sugar Development Foundation and the California Beet Growers Association and released in 1994. These lines have a C37 genetic background, with resistance to rhizomania [caused by beet necrotic yellow vein virus (BNYVV)]. Each line in the C79 series involved a different initial nonrecurrent source that was known or had been identified as having resistance to rhizomania. C37 was chosen as the common recurrent parent because of its adaptation to the western USA. C37's high self-sterility and homozygous green hypocotyls facilitated making and identifying backcrosses. Extractions from breeding lines similar to C37 have been used widely as parental lines in commercial hybrids. C37 is a closely bred, diploid, multigerm line with good resistance to beet curly top virus (BCTV), erwinia root rot, and bolting. C37 is tolerant to virus yellows [caused by beet western yellows virus (BWYV) and by beet yellows virus (BYV)]. It is uniformly susceptible to rhizomania. Except for resistance to rhizomania, C79 lines should be genetically similar to C37.

Lines in the C79 series will segregate for resistance to rhizomania. Because rhizomania resistance was traceable through the backcrossing procedure, it is thought that major resistance is dominant and usually monogenic. Minor and modifying genes may have been lost during the backcross procedure. In general and based on field trial results, line vigor, and to some degree resistance to rhizomania, appeared to become diminished with each backcross to C37.

Rhizomania-susceptible, green-hypocotyl plants of C37 were used as the female recurrent parent. Crosses were made under paper bags as pair plant crosses in the greenhouse. Seed produced on C37 was harvested separately and bulked. From 16 to 24 crosses were made per source per backcross. The F<sub>1</sub>'s were identified by either hypocotyl color and/or resistance to rhizomania. Selections for resistance were made with plants about 4 mo old, grown in uniformly BNYVV-infested field plots. Plots were usually sown in early August after seed had been produced and processed in the early summer. Resistant plants were selected in the field in early December, based on absence of root symptoms, root size and shape, and freedom from bolting. Under these mild fall conditions, escapes were sometimes inadvertently selected.

LEWELLEN, R.T., WRONA, A.F. Solarization and Host-Plant Resistance as Alternatives to Soil Fumigation to Control Rhizomania of Sugarbeet. Proc. 60<sup>th</sup> IIRB Congress, July 1997, Cambridge, U.K.: pp. 189-201. 1997.

Sugarbeet and other crops are grown in a fall plant, spring/summer harvest regime in the Imperial Valley of California (33(N). Fields are often fallow in the intense heat of summer (July mean high (43(C) presenting an opportunity to solarize these high value, irrigated fields in the off-season to control soilborne pests and diseases. Rhizomania is becoming

an increasing concern and problem. The control of rhizomania by solarization and/or host-plant resistance could serve as a model to evaluate alternatives to soil fumigants and specifically to methyl bromide, which is scheduled to lose registration in the USA by the year 2001.

Trials were run from 1993 through 1996. Two separate sites were used and solarization and fumigation treatments were made in the summers of 1993 and 1994. These areas had a history of sugarbeet with rhizomania. At each site, four soil treatments were used with four replications in a randomized complete block design (nontreated control, solarization for 6 weeks under a clear plastic tarp, methyl bromide/chloropicrin under a plastic tarp, and metam sodium shanked into preformed beds without tarping). Cultivars were randomly planted into each main plot. Cultivars included rhizomania susceptible and resistant hybrids. Resistance was from Holly (*Rz*) or *Beta vulgaris* spp. *maritima* (*Bvm*). Subplots were harvested in mid-May and early July. In the second year at each site, sugarbeet was replanted into the same soil treatments to determine if solarization and/or fumigation could be amortized over multiple crops.

At the first site, rhizomania was extremely severe. Methyl bromide fumigation provided the best protection. The relative sugar yields for the control, solarization, methyl bromide, and Vapam( main effects were 100,426,459 and 118%, respectively. For this severe condition, little protection was provided by host-plant resistance alone. Except for the methyl bromide treatment, yields decreased from the first to the second harvest date, largely due to plant death.

At the second site, rhizomania was moderate. Solarization gave the highest yield. The relative performances for the soil treatments were 100,167,151 and 127%. Under solarization, the rhizomania susceptible hybrid had higher yield than the rhizomania resistant entries. In the nontreated check, the USDA experimental hybrid with rhizomania resistance from *Bvm* had the highest yield. In a ranking of the 3-way interaction means, the lowest sugar yield (3300 kg ha<sup>-1</sup>) was for the susceptible cultivar harvested in July from the nontreated condition. The highest yield (11600 kg ha<sup>-1</sup>) was for the hybrid with *Bvm* resistance harvested in July from the solarization treatment.

The plant-back trial showed that there were carry-over benefits to soil solarization. Relative sugar yields for the soil treatments were 100,252,181 and 153%. The highest yield was for the hybrid with *Bvm* resistance grown under solarization with a May harvest (11300 kg ha<sup>-1</sup>). The lowest yield (960 kg ha<sup>-1</sup>) was obtained for the susceptible hybrid in the nontreated control harvested in July that had 57% dead plants.

LI, R.H., G.C. WISLER, H.-Y. LIU, and J.E. DUFFUS. Comparison of diagnostic techniques for detecting tomato infectious chlorosis virus. Plant Dis. 82:84-88. 1998.

A polyclonal antiserum prepared against purified virions of tomato infectious chlorosis virus (TICV) was used to evaluate serological tests for its detection, to determine its distribution in infected plants, to study relationships among isolates of this virus, and to

detect it in field samples. A cRNA probe representing TICV RNA 1 and RNA 2 was used in dot blot hybridization tests. A reverse transcriptase-polymerase chain reaction (RT-PCR) assay was also developed for detection of TICV isolates. The comparative study of these four techniques indicated that RT-PCR was 100-fold more sensitive than enzyme-linked immunosorbent assay (ELISA), Western blot, and dot blot hybridization assays for TICV detection. TICV was detected in leaf, stem, flower, and root tissues of the infected tomato plants. However, the virus was not uniformly distributed throughout the infected tomato plants, and the highest viral concentration was observed in fully developed young tomato leaves at the onset of yellowing symptoms. The virus was detected by indirect ELISA, Western blot, dot blot hybridization, and RT-PCR assays in laboratory-infected tomato, tomatillo, potato, and *Nicotiana clevelandii* and in naturally infected tomato, petunia, and *Ranunculus* sp. Plants obtained from commercial sources. These tests indicate that there are apparently no detectable serological or nucleic acid differences among four TICV isolates obtained from Orange and Yolo Counties of California or from North Carolina or Italy.

WISLER, G.C. and J.E. DUFFUS. New Virus May be Real Threat to Beets. Sugar Producer Magazine 25:20-21. 1998.

During the 1995-96 growing season, severely yellowed sugar beet fields were observed in Colorado and Nebraska. Symptoms initially appeared to be identical to those caused by the luteovirus beet western yellows virus (BWYV) including the interveinal yellowing and necrotic lesions caused by *Alternaria* sp. However, standard indicator plant tests using aphids (this virus is not mechanically transmissible) and serological analyses failed to identify BWYV as the causal agent. Instead, reactions on *Chenopodium capitatum* (interveinal reddening) and lack of reactions on shepherd's purse (*Capsella bursa-pastoris*) indicated this to be distinct from BWYV, resembling a virus previously isolated from California and Texas 10 years earlier, affectionately called "capitatum red" (CPR) because of the red leaf symptoms induced on *C. capitatum*. As studies were initiated at the USDA-ARS in Salinas, California, in collaboration with Dr. Earl Ruppel at the USDA-ARS in Fort Collins, Colorado and Dr. Eric Kerr at the University of Nebraska, attempts were made to obtain a BWYV isolate from surrounding fields for comparative purposes. It was found that "CPR" was also well established in the research fields in Salinas, and may have even had a competitive advantage in the surrounding fields. CPR may be in the breeding program at Salinas because of its unique host range. Field inoculations in recent years have been made with virus yellows isolates collected from naturally infected beets and weed species. To isolate BWYV for large scale production in field trials, aphid inoculation and passage through shepherd's purse was used. To isolate beet yellows virus (BYV), aphid inoculation and passage through *C. capitatum* was used. It is now apparent that when BYV was being passed through *C. capitatum* to purify BYV (or purge BWYV), CPR virus was maintained in the sugar beet source plants used to grow aphids for field inoculations. These initial observations have led to an ongoing research program at the USDA-ARS lab in Salinas aimed at the determination of alternate weed hosts, the source of inoculum for infected beet fields, and the development of assays to distinguish CPR from other related luteoviruses. Researchers in Europe (K. Richards, et al.) have



analyzed the genomes of BWYV and BMV (a common virus in Europe) and indicate the genomes differ significantly to the point that a molecular geneticist would consider these different viruses. The new CPR virus has obvious biological characteristics that make it unique, particularly the host range. The serological and molecular aspects that we and others in France (O. Lemaire, et al.) and England (M. Stevens and H. Smith) are studying are important for understanding the epidemiology of this "new" virus. Thus, it is important to continue to characterize these isolates.

In the first season CPR was detected, it was frequently isolated from beet samples submitted to the Salinas lab from Colorado, Nebraska, and California. Because of its possible widespread occurrence in California, this isolate in particular was incorporated into our breeding program headed by Dr. R.T. Lewellen. Numerous weeds were sampled from surrounding fields but no natural weed source has yet been detected. An experimental host range has been determined by aphid inoculation to a wide range of indicator plants. This virus is difficult to purify, but Dr. Hsing-Yeh Liu has recently been successful with a purification of this virus and it will be used for antiserum production for diagnostic serological assays. Several available antisera have been tested which were prepared to known yellowing luteoviruses including BWYV and beet mild yellows virus (BMV), but neither specifically identifies CPR. Antiserum prepared to CPR previously is a satisfactory test, but improvements need to be made, and this "new" virus still needs to be fully characterized.

In the second year of testing, fewer samples have tested positive from Colorado and Nebraska fields, again only from beet samples submitted. No weed sample from surrounding beet fields submitted to date has been found to be infected with CPR. We assume that, in Colorado and Nebraska, for this virus to survive from one season to another, a perennial or biennial weed must be involved. Otherwise, the virus may have been introduced from stecklings brought in from another location. After the recognition of CPR as a new virus of sugar beet, field tests were run to evaluate economic damage and genetic variability for host plant resistance. Preliminary results suggest that a CPR causes sugar yield losses from about 4 to 40%, depending on the variety. Examples of commercial hybrids grown in Colorado and Nebraska that had no known history of being selected for virus yellows resistance, lost 26-37%. Breeding lines and experimental hybrids from the virus yellows resistance breeding program at Salinas were those that showed the least loss. The lines known to be most resistant to BWYV and BMV also were the most resistant to CPR. Usually, host-plant resistance to different viruses and pathogens is specific, e.g., resistance to beet curly top virus does not protect sugar beet against virus yellows. Because the same breeding lines seem to be the most resistant to BWYV, BMV, and CPR suggests that these three luteoviruses may be closely related. Results from field trials, using varieties that were known to be tolerant to BWYV, also show similar resistance to CPR.

Future research will include sampling beets from a wider geographical area, including commercial areas throughout the west and seed production fields in Oregon. Testing in the beet crops in the following season will help identify the actual source of CPR inoculum, and how widespread it is in the beet production areas. In addition, antisera will



be developed and specific "primers" will be used for amplification of various regions of the virus genome. These "probes" may be useful for diagnosis and distinction of CPR from other luteoviruses which cause yellowing of sugar beets.

WISLER, G.C., J. E. DUFFUS, H.-Y. LIU, and R.H. LI. Ecology and epidemiology of whitefly-transmitted closteroviruses. Plant Disease 82:270-280. 1998.

Several new, bicomponent, whitefly-transmitted viruses which belong to the new Genus Crinivirus, Family Closteroviridae, are described with regard to their epidemiology and ecology. Symptoms of these viruses are the same in all hosts affected, with interveinal yellowing, reddening, and thickening of leaves. Economic losses from these viruses are due to yield reduction based on decreased photosynthetic area. Two viruses which are important in cucurbit production are beet pseudo-yellows virus and cucurbit yellow stunting disorder virus. Two viruses which have affected lettuce production in the sunbelt states of the U.S. are lettuce infectious yellows virus and lettuce chlorosis virus. Two viruses which have recently been found affecting field and greenhouse tomato production are tomato infectious chlorosis virus and tomato chlorosis virus. In addition, at least two new bicomponent, whitefly-transmitted viruses have been found in tomato. All of these viruses can be distinguished by host range differences, whitefly vector specificities, and persistence (longevity) in the vector. With new viruses, specific probes, antisera and even "universal" probes may fail to detect an unknown. Whitefly transmission can be used to recover new viruses from host plants and transmit to test plants for further analysis. These viruses have a significant impact on both agronomic and horticultural plants, and are often moved throughout the world with their whitefly vector. Education of the horticultural industry will aid in recognizing these viruses and managing them in production areas.

WISLER, G.C., R.T. LEWELLEN, J.L. SEARS, H.Y. LIU, and J.E. DUFFUS. Levels of beet necrotic yellow vein virus among resistant and susceptible sugarbeet cultivars grown in rhizomania infested field plots. 7<sup>th</sup> Intl. Congr. Plant Pathol. Edinburgh, Scotland (In press). 1998.

Rhizomania, an economically important disease of sugarbeet, is caused by the beet necrotic yellow vein virus (BNYVV). BNYVV is vectored by *Polymyxa betae*. Viruliferous cystosori survive in soil for many years. Control of rhizomania includes avoidance of infested fields by testing soil for the presence of BNYVV prior to planting, soil fumigation, and use of resistant cultivars. Many sugarbeet cultivars have been bred with varying degrees of resistance to rhizomania. Previous studies [1,2] showed that resistant sugarbeet cultivars differ in levels of BNYVV detected in the roots. Because viruliferous *P. betae* remains in soil after harvest and survives until the next crop is planted, it is important to plant varieties which would not contribute to increasing inoculum levels of BNYVV. The purpose of this study was to evaluate virus content in representative commercial and experimental sugarbeet cultivars developed for production in the United States that range in host-plant reactions to rhizomania from uniformly susceptible to highly resistant.

Field trials were conducted at the USDA-ARS Research Station in Salinas, California, where Rhizomania tests have been made on infested land since 1984 when BNYVV was identified in California. Tests were planted 1 May 1997 in a split-plot design with eight cultivars randomized into three harvest dates (July, August, October) and eight replications. From each plot nine randomly selected beets were analyzed for a total of 72 plants per cultivar and 576 at each harvest date. Each beet was scored for rhizomania disease on a scale of 0-9 (where 0 = no symptoms), weighed, and tested in TAS-ELISA for BNYVV. At final harvest beets were evaluated for root weight and per cent sucrose. Plates were coated with a polyclonal antiserum made to the cloned coat protein of BNYVV, and the monoclonal antibody and conjugate were provided by Agdia, Inc.

Differences in absorbance (A405 nm) values measured among the eight cultivars closely corresponded to a dosage effect and to the frequency of the Rz allele that conditions resistance to BNYVV. A diploid (*Rzrz*) hybrid had a significantly lower value than a similar triploid (*Rzrzrz*) hybrid. Cultivars that segregated (*Rzrz:rzrz*) had higher absorbance values than uniformly resistant (*Rzrz*) hybrids. For all cultivars, differences were observed among harvest dates, with progressively lower absorbance values measured as the season progressed. Absorbance values were significantly positively correlated with rhizomania disease index scores and negatively correlated with individual root weight, plot root weight and sugar yield. This information is useful in resistance breeding and evaluation programs and for the sugar industry in consideration of cultivar choice, inoculum production and rotations for future cropping.

WISLER, G.C., R.H. LI, H.-Y. LIU, D.S. LOWRY, and J.E. DUFFUS. Tomato chlorosis virus: A new whitefly-transmitted, phloem-limited, bipartite closterovirus of tomato. *Phytopathology* 88: (In press). 1998.

Tomato chlorosis virus (ToCV) is the second whitefly-transmitted, phloem-limited, bicomponent closterovirus described infecting tomato. ToCV is distinct from tomato infectious chlorosis virus (TICV) based on lack of serological and nucleic acid cross-reactions and differences in vector specificity. Whereas TICV is transmitted only by the greenhouse whitefly (*Trialeurodes vaporariorum*), ToCV is transmitted by the greenhouse whitefly, the banded wing-whitefly (*T. abutilone*), and by *Bemisia tabaci* Biotype A and B (*B. argentifolii*). Double-stranded (ds) RNA of ToCV show two major dsRNAs of approximately 7,800 and 8,200 bp, with some minor dsRNAs. cDNA clones representing portions of RNA 1 and 2 were used to produce riboprobes using digoxigenin-11-UTP-labeled transcripts. Riboprobes were used in Northern blot hybridizations to detect two major nonhomologous RNAs and a subset of smaller dsRNAs. These probes were used in dot-blot hybridizations to detect ToCV in infected tomato. Inclusion bodies and cytoplasmic vesicles were consistently observed in phloem tissues of ToCV-infected *N. clevelandii*. Computer-assisted sequence analysis of clones that hybridize specifically with RNA 1 and 2 shared significant homology with the lettuce infectious yellows virus methyltransferase of RNA 1 and the HSP70 heat shock protein homolog of RNA 2. Thus, ToCV is another member of the growing subgroup of bipartite closteroviruses transmitted

by whiteflies.

WISLER, G.C., H.-Y. LIU, V.A. KLAASSEN, J.E. DUFFUS, and B.W. FALK. Tomato infectious chlorosis virus has a bipartite genome and induces phloem-limited inclusions characteristic of the closteroviruses. *Phytopathology* 86:622-626. 1996.

Tomato infectious chlorosis virus (TICV) is a newly described closterovirus. Virions purified from TICV-infected plants contained two single-stranded (ss) RNAs, one of approximately 7,800 (RNA 1) and the other 7,400 (RNA 2) nucleotides. Double-stranded (ds) RNA analysis showed two prominent dsRNAs of approximately 7,800 and 7,400 bp, as well as several smaller dsRNAs. The TICV virion ssRNAs were used for cDNA cloning. Of 200 cDNA clones analyzed, 10 clones containing cDNAs ranging in size from about 900 to 1,300 nucleotides were used to generate digoxigenin-UTP-labeled transcripts.

These transcripts hybridized with the TICV ssRNAs in Northern blot hybridization analyses to confirm TICV infection in several host plants including tomato, potato, *Physalis wrightii*, *Nicotiana clevelandii*, and artichoke. None of the probes reacted with any uninfected host plant tested or with plants infected with four other clostero- or clostero-like viruses including lettuce infectious yellows closterovirus, lettuce chlorosis virus, cucurbit yellow stunting disorder virus, and beet pseudo yellows virus. Northern blot hybridization analyses using selected riboprobes showed no detectable homology between TICV dsRNA 1 and 2, or between subsets of smaller dsRNAs. Inclusion bodies, characteristic of the closteroviruses, were consistently associated with the phloem of TICV-infected *N. clevelandii*.

YU, M.H. Registration of Mi-1 Root-Knot Nematode Resistant Beet Germplasm Line. *Crop. Sci.* 37:295. 1997.

The Mi-1 germplasm line of beet (Reg.no. GP-170, PI 593237) segregates for resistance to multiple species of root-knot nematodes in the genus *Meloidogyne*. Mi-1 is the pooled seed increased from the selected root-knot nematode resistant plants of PI 546426, also known as WB 258. Accession WB 258 was originally collected from Po Delta of Italy. It is mostly annual, self-compatible, and varied in plant type and pigmentation. Seedlings were grown in polyethylene containers, inoculated during the fourth- to sixth-leaf stage with 1000 second-stage *M. incognita* Race 1 juveniles per plant, and examined for root gall and protuberance formations 40 days after inoculation. In greenhouse tests, 17% of seedlings from the initial accession were resistant. Seed was increased via interpollination of accession were resistant. Seed was increased via interpollination of 40 resistant plants; more than 55% of Mi-1 seedlings were resistant. Individual plants were classified as resistant that had fewer than 10 root gall and protuberance counts, and with none to low observed nematode reproductions.

Host-plant resistance to BNYVV (beet necrotic yellow vein virus, which causes rhizomania disease symptoms in *Beta*) was identified in accession WB 258; however, such resistance was not expressed in WB 66 (PI 546387) in the same study. The differential

reaction to BNYVV from these two source accessions exhibited the distinction between germplasm line Mi-1 and M66. Mi-1 will be of value for conducting sugarbeet root-knot nematode resistance breeding research.

YU, M.H. Sugarbeet root-knot nematode resistance and breeding aspects. Abstr. 60<sup>th</sup> Congr., IIRB, Cambridge, U.K., p. 102. 1997.

Several of the over 50 species of *Meloidogyne* parasitize *Beta* plants. Sugarbeet (*B. vulgaris* L.) crops grown in root-knot nematode infested fields inevitably produced diagnostic galling symptoms, which resulted in yield loss at various levels. Control of root-knot nematode had been effective through the use of nematicide fumigations. However, such management tactics have increasingly become more difficult mainly because root-knot nematode has a wide range of host plants, including weeds, and numerous regulations have been introduced to limit chemical applications. Consequently development of a sugarbeet variety with root-knot nematode resistance becomes the best, if not the only, option. *Beta* genotypes that carried resistance to root-knot nematode have been recovered. Even though the spectrum of resistance capability against *Meloidogyne* spp. is yet to be investigated, the identified sea beet germplasm is resistant to multiple species of root-knot nematode. An attempt to develop sugarbeet resistant to root-knot nematode was, therefore, started using the resistance which was derived from wild beets.

#### **PAPERS PUBLISHED SINCE ABSTRACTED IN PREVIOUS REPORT**

DUFFUS, J.E., G.C. WISLER, H.-Y. LIU, R.H. LI, G.W. SIMONE and R.C. HOCHMUTH. Whitefly-transmitted tomato leaf yellowing viruses-a disease complex. Pp. 67-68 in Proc. 12<sup>th</sup> Ann. Tomato Dis. Workshop, Columbus, Ohio. 1997.

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## DEVELOPMENT OF SUGARBEET BREEDING LINES AND GERMPLASM

R.T. LEWELLEN

**C69** - C69 (PI 599341) is a multigerm, self-sterile line with resistance to rhizomania (*Rz*) and tolerance to virus yellows (VY). VY tolerance is to both beet western yellows and beet yellows viruses, but resistance to beet western yellows virus is stronger. The VY tolerance was derived from nearly the entire germplasm base of the long term VY USDA-ARS resistance breeding program at Salinas. The *Rz* allele is from lines C78, C79, C80, and C82 that were developed by backcrossing *Rz* into C46/2, C37, C54, and C31, respectively. Plants selected for resistance to rhizomania within C78, C79, C80, and C82 were bulked and used as the pollinator in a composite cross made in the field to rhizomania susceptible stecklings combined from lines C31/6, C39, C46/2, C47, C49, C54, C91, C92, Y48, Y56, and Y57. Plants selected for resistance to rhizomania from this composite cross were crossed in the field to a bulk of green hypocotyl stecklings from breeding lines C31/6, C31-43, C31-89, C39, C49, and C91. Both hypocotyl color and resistance to rhizomania were used as markers to identify F<sub>1</sub> plants from this second composite cross called Y569. Y569 is predominantly the germplasm of C31 with smaller amounts from C37, C46, C39, C64, and other sources. Y569 was planted in early May under moderately severe rhizomania conditions at Salinas. In July, the selection plot was inoculated with sugarbeet *Erwinia*. Powdery mildew and *Cercospora* leaf spot were not controlled and were moderate on susceptible plants. A high incidence of natural infection with beet western yellows virus occurred. Phytophthora tip rot was prevalent and differentially damaged breeding lines in this planting. In late November, individual plants were selected based upon root yield and conformation and resistance to rhizomania, root rots, *Cercospora* leaf spot, and powdery mildew. Roots visually selected in the field were reselected for sucrose concentration. Following vernalization, the mother roots were increased in mass to produce breeding line Y769, released as C69.

Preliminary tests show that C69 has relatively high sucrose concentration, good root and agronomic traits, large canopy and combined disease resistance. At most the frequency of *Rz* allele will be 50%. Based on the average performance of the lines in the composite crosses, C69 should have good resistance to *Erwinia* and moderate resistance to VY, powdery mildew, and bolting. C69 is moderately susceptible to curly top. In preliminary evaluations, C69 showed higher sucrose content than C78 or C80. C69 should be useful as a broadbased source for continued population improvement and from which parental lines with combined resistance could be extracted.

**C67** - C67 (PI 599340) and C72 (PI 599342) are multigerm, self-sterile lines with resistance to rhizomania and tolerance to virus yellows (VY). VY tolerance was derived from advanced lines developed in the long term VY resistance breeding program at Salinas. Rhizomania resistance is conditioned by both the *Rz* allele and factors(s) from C51 (breeding line R22) that gives a high level of resistance under severe conditions. R22 is a population derived from sugarbeet x *Beta vulgaris* subsp. *Maritima* (*Bvm*). C67 is

estimated to have about 10% *Bvm* germplasm. A version of breeding line R22 called R322Y3% selected for combined resistance to rhizomania, virus yellows, and agronomic traits including sugar concentration, root conformation, and nonbolting was crossed in the greenhouse to lines C37, C78, C80, and C82. Plants from each cross-selected for resistance to rhizomania at Salinas were composited and used as the pollinator in a field seed plot. In addition, this pollinator composite included resistant plants from the two backcross lines used to produce C72. This pollinator composite was crossed onto a female composite comprised of green hypocotyl stecklings selected from lines C31/6, C31-43, C31-89, C39, C49, and C91. Both hypocotyl color and resistance to rhizomania were used as markers to identify F<sub>1</sub> plants from this composite cross called Y567. Y567 was planted in early May under moderately severe rhizomania conditions at Salinas. In July, it was inoculated with sugarbeet *Erwinia*. Powdery mildew was not controlled and was moderate. In late November, individual plants were selected based upon resistance to rhizomania, *Erwinia*, and powdery mildew and for root yield and conformation. Selected roots were reselected for sucrose concentration and after vernalization, increased in mass to produce a breeding line Y767, released as C67. Based on a comparison of the selected roots from a number of breeding lines under similar conditions, C67 should have good agronomic traits, combined disease resistance and sucrose level. In observations under severe rhizomania in the Imperial Valley, about 50% of the plants showed high resistance to rhizomania and survivability in late June when similar lines with only *Rz* resistance had died. It is not yet known if factors for VY resistance beyond those from the sugarbeet lines were acquired from the R322Y3% version of C51.

**C72** - C72 is estimated to have about 5% of its germplasm from wild beet germplasm (*Bvm*). Breeding line R22 was crossed to C37. Plants resistant to rhizomania were selected from the F<sub>1</sub> generations and three successive backcrosses made to C82 to produce a backcross line 5284 that would theoretically be about 3% *Bvm*. In a second series of crosses, line R22 again was crossed to C37 and then rhizomania resistant plants selected and backcrossed twice to C80 to produce backcross line 5280 that would be about 7% *Bvm*. Lines C82 and C80 were the source of *Rz*. From lines 5284 and 5280, plants resistant to rhizomania were selected at Salinas, combined and increased in mass to produce line Y672. Y672 was again mass-selected for resistance to rhizomania to produce line Y772 and released as C72. C72 has not been extensively evaluated but in trials under severe rhizomania in the Imperial Valley, about 50% of the plants showed the high resistance and survivability under high-temperature conditions attributed to the C51 source. At Salinas under moderate rhizomania, most plants were resistant and *Rz* and C51 types of resistance could not be distinguished. C72 should be a source from which sugarbeet lines with C51 (R22) resistance can be extracted.

**CZ25** - CZ25 (PI 599343) is a multigerm, self-fertile (*S*<sup>f</sup>) population that segregates for genetic male sterility (*aa*) and hypocotyl color and for resistance to rhizomania (*Rz*-). About 37% of the germplasm of CZ25 was derived from high sugar lines obtained from Poland in 1988. Breeding lines from the Janasz Station in Poland are well known for their very high sucrose concentration. This germplasm is believed to be widely used in many commercial hybrids around the world. Conversely, this germplasm also is known for its high susceptibility to almost all diseases of sugarbeet that occurs in southern temperate



areas. To be more useful in California and the western USA, this high sugar germplasm needs to be combined with multiple disease resistance. Nine Polish (2x-18,MM,S<sup>s</sup>S<sup>s</sup>,type-ZZ) lines were received from Dr. Adam Szreder, Hodowla Buraka Cukrowego, Poland, for use in the Salinas breeding program. These nine accessions were individually evaluated at Salinas for performance, disease resistance, and adaptation. Accessions 2 and 4 appeared to have the best combination of traits and were maintained individually. Otherwise, all nine accessions were combined into a single composite population. The composite and two individual lines were crossed to population-912 (MM,S<sup>s</sup>,Aa,Rz), a predecessor to population-918 (C918). Plants from within these three F<sub>1</sub> lines were selected for resistance to rhizomania, agronomic traits, and adaptation and increased. A second cycle of selection for resistance to rhizomania was made and the rhizomania resistant plants from these three lines were recombined into a single population named Z325 (50% Polish). Plants from Z325 were individually selfed under paper bags in the greenhouse, and the selfed seed was composited to produce Z625(C). In 1992 a composite of rhizomania resistant roots from the three F<sub>1</sub> lines also was crossed to population-915 (similar to C918) to produce a population named Z430 (25% Polish). Plants from Z430 were selfed and seed composited to produce Z630(C). Plants from Z625(C) and Z630(C) were recombined into one population through their genetic male-sterile segregates to produce CZ25 (about 37% Polish of which about equal proportions come from Polish lines 2,4, and nine- line composite).

Plants from distributed seed of CZ25 will be multigerm, mostly self-fertile, and segregate for genetic male sterility (Aa:aa) and resistance to rhizomania (Rz:·r<sub>z</sub>r<sub>z</sub>). The line will not be in genetic equilibrium. One or more increases through the genetic male-sterile segregates is recommended. An additional course of action would be to self individual (Aa) plants to produce S<sub>1</sub> progeny. These S<sub>1</sub> lines could then be evaluated to estimate genetic diversity and usefulness of the population and to select for highly heritable and additive traits such as disease and bolting resistance, sucrose concentration, and juice purity. CZ25 has not been evaluated, but based upon the performance of its component lines (Z220, Z230, Z325, Z330, and Z430), it should be possible to identify plants and lines with moderate levels of resistance to most important diseases in the western USA in a higher quality background than the standard Salinas germplasm.

#### **INHERITANCE OF POWDERY MILDEW RESISTANCE IN SUGARBEET DRIVED FROM *BETA VULGARIS* spp. *MARITIMA***

Resistance to powdery mildew was identified in wild beet accessions by J.S. McFarlane and E.D. Whitney. Resistance in WB97 and WB242 has been transferred into sugarbeet breeding lines. Those enhanced lines were the source for breeding material used to study the inheritance of this resistance. Individual plants from the enhanced sugarbeet lines were used in controlled crosses and selfs to determine segregation patterns. Testcross and S<sub>1</sub> families were either fully susceptible or discretely segregated for reaction to *Erysiphe polygoni*. Families that segregated were tested for goodness-of-fit by ( $\chi^2$ ) analysis to the appropriate ratios. Most segregating families fit the pattern expected for a single, dominant gene. The results of field test 1197 showed that resistance to powdery mildew from WB97 and WB242 was inherited as a single, dominant factor. The gene symbol *Pm* is proposed for

this resistance.

### **REACTION OF BREEDING LINES TO CAPITATUM RED LUTEOVIRUS**

**(CRV) (R.T. Lewellen, G.C. Wisler, H.-Y. Liu, J.E. Duffus, S.R. Kaffka )** - Virus yellows is a complex of aphid vectored viruses that may include beet yellows virus (BYV), beet western yellows virus (BWYV), beet mosaic virus (BMV), and in Europe, beet mild yellows virus (BMYV). Recently, a new luteovirus was recognized in California, Texas, Colorado, and Nebraska. This luteovirus called here capitatum red virus (CRV), is somewhat similar to BWYV and/or BMYV but infects *Chenopodium capitatum* whereas BWYV and BMYV do not. Symptom expression in sugarbeet is also similar to BWYV and/or BMYV but appears to be slightly more severe with greater interveinal yellowing. The economic effects of this virus on sugarbeet and the range in host-plant reaction (genetic variability for resistance) were unknown. Tests of breeding lines and hybrids were grown and inoculated with CRV at Salinas and Davis in 1997. The following results and observations are from the Salinas tests.

Breeding lines were grown in companion yield tests 1597 and 1897. Test 1597 was inoculated with CRV. Yield losses were estimated by the difference in performance for sugar yield between the individual entries in these tests. On average, there was an 18% loss due to CRV. Individual breeding line losses ranged from 4% for C913-70 to 30% for US75 (an obsolete MM,O.P. variety derived from CTR US22/3 and grown commercially in California in the 1950's). Losses for a CTR monogerm population composed of germplasm from C562, C546, C718, etc. showed a 37% loss. In general, the lines that showed the most resistance (least loss) were those from the virus yellows breeding program at Salinas and that had been released as being partially virus yellows resistant. These lines such as C713-70, C76-89-5, C69, C39, C37 are the ones that would also have shown the most resistance to BWYV and probably to BMYV.

PERFORMANCE OF BREEDING LINES UNDER CRV  
Salinas, 1997

<u>Variety</u>	<u>Description</u>	<u>Sugar lbs/a</u>	<u>% Loss</u>	<u>Yellowing Score</u>
US 75	susceptible check	4400	30	5.4
C37	VYR, rzzrz check	5300	11	3.4
C76-89-5	VYR, Rz line	9500	9	2.6
C913-70	VYR, Rz line	9900	4	2.9

Pltd 4-10-97, Inoc.CRV 6-10-97, Harv. 10-7-97.  
VY scored from 0 to 9 where 0 = completely green.  
Moderate rhizomania conditions.

PERFORMANCE OF BREEDING LINES UNDER CRV  
Salinas, 1997

Variety	Description	Sugar lbs/a	% Loss	Yellowing Score
US 75	susceptible check	4400	30	5.4
C37	VYR, rzzr check	5300	11	3.4
C69	VYR, Rz composite	10200	9	3.4
R22Y	<i>B.maritima</i> source	8600	11	3.1
Y67	VYR, <i>Bvm</i> line	9700	12	3.0
6835	<i>mm</i> , CTR popn	5713	37	5.1

Pltd 4-10-97, Inoc.CRV 6-10-97, Harv. 10-7-97.  
VY scored from 0 to 9 where 0 = completely green.  
Moderate rhizomania conditions.

Hybrids were grown in companion yield trials 1997 and 1997. Test 1997 was inoculated with CRV. Estimated losses ranged from 2% for R581H50 (= C790-15CMS x C82) to 37% for commercial hybrids. Hybrids with C913-70 showed resistance as did experimental hybrid R680H7 (= 5911-4-7CMS x C80). The line 5911-4-7 is from a monogerm extraction from line C911-4 that also shows resistance. The most susceptible commercial hybrids were those that were not adapted to California and had not been developed from California germplasm. These susceptible hybrids have been grown in Colorado and Nebraska where CRV in several recent years caused significant damage.

#### **RESISTANCE TO RHIZOMANIA AT HIGH TEMPERATURES -**

As previously related, breeding line R22 (C51) that is an improved population of composite crosses between sugarbeet and *Beta vulgaris* spp. *maritima* shows high resistance under the combined influences of rhizomania and high temperature. This resistance seems to be different than that conditioned by *Rz*. The R22 resistance appears to be fairly simply inherited and in being backcrossed into sugarbeet breeding lines with adaptation to Imperial Valley of California. Trials in 1997 at Brawley showed that these backcross lines have better survival rates than their *Rz* recurrent parents. For example, R636 (12% *Bvm*) and R646 (6% *Bvm*) had survival rates in late June of about 80% compared to about 40% for similar *Rz* lines R678 and R680. Likewise the backcross series Y664 (25% *Bvm*), Y667 (12% *Bvm*), and Y672 (3% *Bvm*) had between 80 and 90% survival compared to about 40% for C78 and C80.

REACTION TO RHIZOMANIA AT HIGH TEMPERATURES  
Brawley, 1997

Variety	Description	%Bvm	%Survival
US H11	Susc. check	0	14
R522	R22,C51,Bvm resist.	50	100
R678	C78,Rz resistance	0	32
R680	C80,Rz resistance	0	48
R636	BC <sub>2</sub> (C37 x R22)	12	73
R646	BC <sub>3</sub> (C37 x R22)	6	83
Y664	BC <sub>1</sub> (C78,C80 x R22)	25	88
Y667 (C67)	BC <sub>2</sub> (C78,C80 x R22)	12	87
Y672 (C72)	BC <sub>4</sub> (C78,C80 x R22)	3	84

%Bvm = estimated Bvm germplasm

%Survival = living plants on 25June1997

### **DEVELOPMENTS FROM COMPREHENSIVE BREEDING PROGRAM**

**(EXAMPLE 1: LINE 4911-4-10)** - Funding is received from the BSDF for breeding for resistance to virus yellows (210) and rhizomania (215) and for population improvement (211). These grants plus others received from the California Industry Research Committee fund a comprehensive breeding program that as a whole includes everything involved in a conventional sugarbeet breeding program. Two examples of breeding lines under development will be given to illustrate this comprehensive program and how end products may be useful to the California industry where primary breeding efforts have dwindled.

Breeding line 4911-4-10 is an increase of an S<sub>1</sub> extraction from multigerm, self-fertile, genetic male-sterile facilitated random-mated population 911. Popn-911 has been under long term population improvement to combine multiple disease resistance and performance. From popn-911, half-sib line C911-4 was extracted and released. From C911-4, S<sub>1</sub> lines were generated and evaluated for performance and resistance to virus yellows, rhizomania, Erwinia, powdery mildew, bolting, etc. From these S<sub>1</sub> evaluations, line 4911-4-10 was selected as possessing desirable combinations of traits.

#### BREEDING LINE 4911-4-10

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4911-4-10 is a multigerm, nonbolting breeding line that combines resistance to rhizomania, virus yellows & Erwinia

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Experimental hybrids were made with 4911-4-10 and evaluated in 1997 in tests at Salinas and Brawley.

# HYBRID EVALUATION OF LINE 4911-4-10

Hybrid	Sugar lbs/a	% Sucrose
CMS x 4911-4-10	11100	15.6
SS 781	9500	13.5
Rival	10300	15.0

Mean of four tests at Brawley & Salinas in 1997.

If continued evaluations show that 4911-4-10 has potential merit, it will be released. What 4911-4-9 at this point may illustrate is the potential of long term population improvement followed by S<sub>1</sub> progeny evaluation to identify superior genotypes.

## DEVELOPMENTS FROM COMPREHENSIVE BREEDING PROGRAM

**(EXAMPLE 2: 5833-5)** - Monogerm lines are needed on the other side of the hybrid from multigerm lines such as 4911-4-10 to produce commercial hybrids. An example from my program of a monogerm line under development is line 5833-5. Line 5833-5 is an S<sub>1</sub> extraction from population improvement within monogerm germplasm. The development of 5833-5 in my program started in about 1968 when monogerm, self-fertile, genetic male-sterile facilitated, random-mated populations were developed. Initially one of these populations was called popn-767.

TABLE 1.

1968-1983

Development of population-767 (popn-767)

Monogerm, type-0, self-fertile, genetic male-sterile facilitated, random-mated population

Genetic structure

mm, S<sup>r</sup>, A:aa, type-0

Population improvement

Host-plant resistance (NB, CTR, VYR, ...)

Combining ability (hybrid performance)

Sugar yield, %S, juice purity

When rhizomania was recognized as a problem in 1983, popn-767 was crossed with a source of resistance to rhizomania to develop popn-867. Although commercially used monogerm lines were developed by the seed industry from popn-867, it had major deficiencies.

TABLE 2.

1984-1993

Combine resistance to rhizomania with popn-767

popn-767	x	Rz (Holly resistance)
(		
popn-867 (Rz )		

Traits:	mm	variable
	T-O	poor
	NB	intermediate
	CTR	intermediate
	%S	low
	yield	high GCA

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Popn-867 released. Source of RzRz commercial parental lines.

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Among the major deficiencies that were contributed by the resistance to rhizomania source were poor monogermity, poor O-type traits, lower CTR, and less bolting resistance. To attempt to improve those traits, popn-867 was crossed to a composite of lines known to have good monogerm and O-type and high CTR and NB to produce a new population called 4833 (popn-833).

TABLE 3.

1994

Recombine popn-867 with better sources of mm, type-O, CTR, NB

Popn-867 (Rz )	x	mm, T-O, CTR, NB
(		(C562, C546, C718,
		C762-17, C796-43)
4833		

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From popn-833, S<sub>1</sub>'s were generated.

Table 4

1994-1995

Seed of 4833 planted in August 1994  
rhizomania nursery, resistant plants  
selected and induced to bolt, and in 1995  
individual plants selfed (()) in greenhouse

RZM 4833mm (
(
S <sub>1</sub> progeny lines 5833-1
-2
-n

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To evaluate these randomly generated S<sub>1</sub> lines, they were topcrossed to produce experimental hybrids.

Table 5.  
1995-1996

Topcross hybrids produced for evaluation of S<sub>1</sub> progeny lines.

Seed of S<sub>1</sub> lines planted in August 1995 steckling nursery at Medford, Oregon, stecklings transplanted in March 1996 at Salinas, and topcrossed to R78 tester.

Topcross hybrid	S <sub>1</sub> line	x	Tester
R78H33 -1	5833 -1		R78
-2	-2		R78
-n	-n		R78

These topcross experimental hybrids were evaluated in tests at Salinas and Brawley in 1997.

Table 6.  
1997

Topcross hybrids evaluated at Brawley and Salinas

Location	Test No.	Traits
Brawley	B397	Yield, bolting
Salinas	297	Bolting
Salinas	1497	Erwinia, Powdery mildew
Salinas	2297	Yield (mod. rhizomania)
Salinas	3797	Yield (severe rhizomania)

For example, in the Brawley test, they were compared to the experimental hybrid R78H50 that used a monogerm female line of known performance. In Table 7, hybrids produced with S<sub>1</sub> lines 5833-2 and 5833-5 are contrasted. This contrast shows that under the conditions of this test, 5833-2 had lower combining ability for sugar yield than line 5833-5, and gave an estimate of the realizable genetic variability within popn-833.

Table 7. EVALUATION OF TOPCROSS HYBRIDS, BRAWLEY

Hybrid	Description			Sugar lbs/a	% Sucrose	% Bolting
	S <sub>1</sub> line	x	Tester			
R78H50	check		R78	9900	14.1	0.9
R78H33-2	5833-2		R78	8700	12.9	1.8
R78H33-5	5833-5		R78	10700	14.3	0.0
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LSD (.05)				1000	0.8	

Test B397: 48 var x 8 reps, RCB;  
Planted Sep. 11, 1996; Harvested May 11, 1997.

The same two topcross hybrids were contrasted in two tests at Salinas. These tests support the Brawley evidence that these S<sub>1</sub> lines have different potentials for sugar yield and that 5833-5 is superior to 5833-2.

Table 8. EVALUATION OF TOPCROSS HYBRIDS, SALINAS

Hybrid	Description		Sugar lbs/a	% Sucrose
	S <sub>1</sub> line	x Tester		
R78H50	check	R78	9400	13.5
R78H33-2	5833-2	R78	9700	13.4
R78H33-5	5833-5	R78	12200	15.7
LSD (.05)			800	0.6

Test 2297: 48 var x 8 reps, RCB;  
April 11, 1997; Sept. 23, 1997.  
Moderate rhizomania.

Table 9. EVALUATION OF TOPCROSS HYBRIDS, SALINAS

Hybrid	Description		Sugar lbs/a	% Sucrose
	S <sub>1</sub> line	x Tester		
R78H50	check	R78	7600	15.0
R78H33-2	5833-2	R78	8100	13.9
R78H33-5	5833-5	R78	9800	15.8
LSD (.05)			900	0.8

Test 3797: 32 var x 8 reps, RCB;  
May 2, 1997; Nov. 5, 1997.  
Severe rhizomania.

I suppose the proof in the pudding is actually how well the topcross hybrid with 5833-5 stood up to the commercial checks. Table 10 suggests that 5833-5 may be worth further evaluation and development.

Table 10. EVALUATION OF TOPCROSS HYBRIDS

Hybrid	Description		Sugar lbs/a	% Sucrose
	S <sub>1</sub> line	x Tester		
R78H33-5	5833-5	C78	10900	15.3
SS 781R	Spreckels		8800	13.6
Rival	Holly		9200	14.9
Beta 4776R <sup>2</sup>	Betaseed		10900	15.0

<sup>1</sup>Mean of three tests at Brawley & Salinas

<sup>2</sup>Beta 4006R at Brawley & 4776R at Salinas

Based upon the above information from the 1997 tests, line 5833-5 will be maintained in the breeding program at Salinas.



Table 11.

1998

Retest R78H33-5 ( $S_1$  progeny line 5833-5)

Increase 5833-5 & cross to CMS

(individual  $S_1$  plants in greenhouse to produce  $S_2$  lines  
and cross to T-O index tester

Remake experimental hybrids  
5833-5 x pollinators

In the future, the Salinas program will attempt to identify  $S_2$  lines that combine good monogerm and O-type traits, homozygosity for  $R_z$ , high CTR and NB, and that maintain good %S with high combining ability for sugar yield.

Table 12.

1999

Identify  $S_2$  lines that are *mm*, T-O  
Identify  $S_2$  lines that are  $R_zR_z$  & high %S  
Identify  $S_2$  lines that have high CTR & NB

Test new experimental hybrids involving 5833-5

Make decision on future of line

Based upon further testing and development, a decision will be made about the release of a 5833-5 type line. Of course in the dreams and imagination of the principle investigator, the two lines in these two examples will be used to produce a single-cross hybrid that is superior to anything being grown in California. This hybrid C833-5CMS x C911-4-10 would combine high sugar concentration and yield with combined resistance to rhizomania, virus yellows, *Erwinia*, powdery mildew, curly top, bolting, etc.

**EVALUATION OF INDUSTRIAL CHICORY** - Cultivars of chicory (*Cichorium intybus* L.) have been developed for inulin production. Inulin or fructosugars have potential use as fructose sweeteners, sugars for consumption by insulin-dependent diabetics, and, in higher polymer units, as non-caloric substitutes for fat in food. In 1997 at Salinas and Brawley, cultivars of industrial chicory were evaluated for yield, bolting, and adaptation. In overwintered production in the Imperial Valley, average yields were low (12 tons/a). However, in the Salinas Valley, a March planting with October harvest gave average yields of 37.6 t/a with 23.3% brix and no bolting in most cultivars. About 14,000 lbs. inulin per acre was estimated. In a comparative sugarbeet planting, commercial hybrids were producing about 12,000 lbs. sugar per acre. Based upon the four trials at Salinas, chicory performed well and was essentially disease free.

**INHERITANCE OF POWDERY MILDEW RESISTANCE IN SUGAR BEET  
DERIVED FROM *BETA VULGARIS* spp. *MARITIMA* (R.T. Lewellen and J.K.  
Schrandt) -**

Powdery mildew of sugar beet (*Beta vulgaris* L.) caused by *Erysiphe polygoni* DC. became important in the United States in 1974 after apparently being introduced into the Imperial Valley (Ruppel et al., 1975). Traditional North American sugar beet cultivars and germplasm largely proved to be highly susceptible. Yield losses greater than 30% were measured (Skoyen et al., 1975). Powdery mildew has been successfully controlled with fungicides (Hills et al., 1980). Particularly in the western USA, one or more fungicide applications are required on every crop. Resistant cultivars are needed. Partial resistance of a slow-mildewing type has been identified in sugar beet germplasm (Whitney et al., 1983). Breeding lines with moderately high partial resistance have been developed, e.g., C39 (Lewellen, 1995). Commercial hybrids with partial resistance have also been made available to growers by the sugar beet seed industry. A search of *Beta* genetic resources identified high levels of resistance in *B. vulgaris* spp. *maritima* L. On the basis of field observations, McFarlane (unpublished, *Beta* Germplasm Preservation, 1982) identified accessions with high resistance. Subsequently in controlled greenhouse evaluations, Whitney (1989) confirmed that WB97 (wild beet accession 97) and WB242 had individual plants that showed high resistance. WB97 was accessed by the Salinas station in 1968 from the Japan Sugarbeet Improvement Foundation. The Japanese obtained this line in 1963 as WB46 from a collection at Wageningen, the Netherlands. McFarlane made seed increases in 1977 and 1978. His field tests in 1980 showed that it was an annual of mixed plant types and individual plants were highly resistant to powdery mildew. WB242 was received from Bergen op Zoom, the Netherlands, in 1974. Passport data showed that it was originally collected as *B. vulgaris* spp. *maritima* from the Loire River Estuary in France. It also has been shown in the Netherlands to be partially resistant to sugar beet cyst nematode (*Heterodera schachtii* Schmidt). WB242 was increased at Salinas in 1979. In McFarlane's 1980 field test, WB242 was mostly annual, highly variable for plant type with both erect and procumbent stem growth, and most plants were highly resistant to powdery mildew. The relationship between WB97 and WB242 is unknown.

High resistance and major gene resistance to *Erysiphe polygoni* in sugar beet has not been previously known or reported. The purposes of this research were to enhance sugar beet germplasm with high resistance to powdery mildew from the WB97 and WB242 sources and to determine the inheritance of this resistance from WB97 and WB242.

**MATERIALS AND METHODS**

**Plant material.** WB97 and WB242 were used as sources of resistance to powdery mildew. After the initial crosses with sugar beet, a series of backcrosses were made to transfer this resistance to sugar beet and eliminate as quickly as possible the weedy traits of *B. vulgaris* spp. *maritima*. Selection for resistance to powdery mildew was not made after every backcross, but was practiced often enough to maintain resistance in the backcross lines. For backcross lines P401, P402, P403, and P404 (Table 1), the final backcross was made from plants selected for resistance. Line P405 (Table 1) was produced from unselected plants. Backcross lines P403 and P404 were developed in a

self-sterile C37 (Lewellen et al., 1985) background from WB97 and WB242 sources of resistance, respectively. P402 was initially from a cross to C37 with the two backcrosses being made to C918. C918 is self-fertile and segregates for genetic male sterility. Whereas self-sterile plants will not self under paper bags in the greenhouse at Salinas, pollen fertile, self-fertile genotypes readily self permitting the production of seed of  $S_1$  progeny lines. The segregation for genetic male sterility in this line facilitates backcross and testcross families to be made. P405 is similar to P402 but C309 (Lewellen and Skoyen, 1988), a monogerm, self-fertile line that segregates for genetic male sterility was used for the two backcrosses. For P401, P402, and P405, resistant plants derived from both WB97 and WB242 were mixed during development and no attempt was made to maintain separate identities. The  $F_2$  lines P601, P603, and P604 were individually produced in mass from plants from P401, P403, and P404, respectively, that had been selected in the field for resistance to powdery mildew.

To set up the testcross and  $S_1$  families for the inheritance of resistance study, backcross lines P403 and P404 were grown in the field at Salinas in an August planting. Powdery mildew incidence was very mild under these late planted conditions and escapes would be common. What would be equivalent to  $F_1$  plants without visible mildew was selected. Selected plants were photo-thermally induced in cold rooms and used to produce testcrosses. For lines P402 and P405, plants for testcrossing and selfing were randomly obtained from stocklings produced in overwintered nurseries in Oregon without reaction to powdery mildew being known. Testcrosses and selfs were made in the greenhouse under paper bags. Plants of P403 and P404 were individually crossed to single plants of C37 to produce testcross families called 6201 and 6205, respectively (Table 2). Seed from each plant of the pair cross was maintained separately as pair cross reciprocals. Plants of P402 were crossed to individual plants of C918. Pollen fertile plants of P402 were used as the pollinator and crossed to genetic male sterile plants of C918 and simultaneously selfed to set up corresponding testcross and  $S_1$  families called 6211 and 6212, respectively (Table 2). Plants of P402 that were genetic male sterile were used as the seed bearing parent and crossed to fertile plants of C918. From these pair crosses, the selfed seed produced on C918 was discarded. Extra fertile plants of P402 were only selfed. P402 segregated for self-sterility, thus not all corresponding  $S_1$  lines could be made. The same procedure as for P402 was used for P405 except C309 was used as the susceptible tester. Corresponding testcross and  $S_1$  families were called 6221 and 6222, respectively (Table 2). In addition because C309 has a cytoplasmic male sterile equivalent called C309CMS, some test crosses were made to cytoplasmic male sterile plants. For all testcrosses and selfs, identity of seed from each plant and cross was maintained.

**Inoculation.** All evaluations were made in the field at Salinas, CA. Since 1974 when powdery mildew first occurred (Ruppel et al.), moderate to severe epiphytotics have naturally occurred at Salinas.

**Resistance evaluation.** Checks, parental lines, testcross and  $S_1$  families were tested in field plots at Salinas (Tables 1,2, and 3). 'US H11' was used as a susceptible check and in spreader rows around the trial area. Parental lines C37, C918, and C309 were systematically placed throughout the trial. Plots of the source populations P401, P402,

P403, P404, and P405, along with powdery mildew resistant selected versions, were systematically placed among the plots of the testcross and S<sub>1</sub> families. Depending upon seed quantities available, each testcross and S<sub>1</sub> family was represented in one or two plots. Reciprocal seed from each plant of a pair cross was tested in separate plots. Following inspection of the plots and data, the counts for the corresponding reciprocals and repetitions were combined for each family.

The test was planted March 4, 1997. Individual plots were 3m long with a 0.6m alley. Single-row plots were 72cm wide. Following over-seeding, plants were carefully thinned and singled to about 15cm spacing. Best cultural practices with sprinkler irrigation were used to obtain vigorous plants. Powdery mildew first appeared in late June. On a plot basis, plots were scored for reaction to powdery mildew on a scale of 0 to 9 where 0 = no evidence of mildew to 9 = 90-100% of visible mature leaf area covered with mildew. Scoring was done on July 12 and 29, 1997.

Counts were made on July 21 on all plots (Table 1). Because a few plants within known fully susceptible checks still appeared resistant and it was very difficult to accurately separate individual plants within a plot, it was decided to recount all testcross and S<sub>1</sub> families on August 8, by carefully pulling and separating plants. At this date, powdery mildew severity and uniformity appeared to be at its peak. For counts, only two classes were used: resistant vs. susceptible. Plants counted as resistant would have been rated as 0 or 1 and if they had visible mildew, it was only on the oldest leaves and very sparse. This criterion for resistance was based upon the observation in the segregating source populations that reaction to powdery mildew fell into fairly discrete resistance and susceptible types.

**Data analysis.** Count data for each progeny family was examined. Because backcross generated plants were used to make the testcrosses and S<sub>1</sub>'s, they could have been either resistant or susceptible. Families that appeared to have discrete segregation into resistant and susceptible classes were individually analyzed for the appropriate goodness-of-fit to a single dominant gene model using  $\chi^2$  analysis (Table 2). Families from common source lines were pooled and  $\chi^2$  tests for heterogeneity run. Families that appeared to be fully susceptible or had very low numbers of resistant plants were pooled (Table 3). Where corresponding testcross and S<sub>1</sub> families occurred, these were listed individually (Table 3).

## RESULTS AND DISCUSSION

High resistance to *E.polygoni* found in *B.vulgaris* spp. *maritima* accessions WB97 and WB242 was transferred to sugar beet by recurrent backcrosses. These enhanced sugar beet lines continued to show discrete segregation for reaction to powdery mildew (Table 1). Individual plants from the enhanced sugar beet lines were used in controlled crosses and selfs to determine segregation patterns. Testcross and S<sub>1</sub> families were either fully susceptible or segregated for resistance (Tables 2 and 3). Families that segregated were tested for goodness-of-fit to the appropriate ratios. Most segregating families fit the pattern expected for a single, dominant gene (Table 2). The results of this field test showed that this resistance to powdery mildew was inherited as a single, dominant factor.

The tests for heterogeneity also showed that these segregating families represented a single population. The name and gene symbol for this resistance factor are proposed to be *Pm*.

There is a chance that the resistance factors from WB97 and WB242 are different. This allelism was not tested in this program. Even though enhanced lines P401, P402, and P405 were of mixed WB97 and WB242 ancestry, there was never an opportunity for recombinations within these enhanced lines. Thus no individual families would have shown dihybrid ratios if these lines had different resistance factors.

To our knowledge, this resistance has never been used commercially in sugar beet. Dominant, major gene resistance to powdery mildew in crop plants has been notorious for lack of durability. Because resistance conditioned by *Pm* has not been deployed beyond a few research plots, there has been little pressure for resistance breaking races of *E. polygoni* to occur or to be selected. In the field trials at Salinas through 1997, there was no evidence of this resistance being defeated.

## ACKNOWLEDGEMENTS

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TEST 1197. INHERITANCE OF RESISTANCE TO POWDERY MILDEW, 1997

TABLE 1. Distribution and score of sugarbeet plants and plots for reaction to powdery mildew in segregating checks, recurrent parents, and source lines.

Mildew	Checks and Parental Sources	Reaction to Powdery			
		R	S	Score <sup>2</sup>	
		(no. of plants <sup>1</sup> )		7-12-97	7-
<u>29-97</u>					
<u>Check</u>					
US H11	susceptible check	11	403	2.8	7.9
<u>Recurrent &amp; Testcross Parents</u>					
C37	susceptible parental line	18	163	3.6	7.8
C918	susceptible parental line	42	136	1.6	6.4
C309	susceptible parental line	1	136	4.1	8.8
<u>Backcross Derived Source Lines</u>					
P401	BC <sub>2</sub> F <sub>1</sub> (C37*3 x WB97 & 242)	13	12	3.0	5.5
P601	BC <sub>2</sub> F <sub>2</sub> PMR sel. P401	19	7	2.0	4.5
P402	BC <sub>2</sub> F <sub>1</sub> (C918*3 x WB97 & 242)	75	76	1.5	6.3
P403	BC <sub>4</sub> F <sub>1</sub> (C37*5 x WB97)	24	24	2.0	6.0
P603	BC <sub>4</sub> F <sub>2</sub> PMR sel. P403	40	11	1.3	4.3
P404	BC <sub>3</sub> F <sub>1</sub> (C37*4 x WB242)	26	21	2.0	5.3
P604	BC <sub>3</sub> F <sub>2</sub> PMR sel. P404	43	6	1.5	3.8
P405	BC <sub>2</sub> F <sub>1</sub> (C309*3 x WB97,242)	18	82	3.4	7.1

<sup>1</sup>Counted on 7-21-97 without pulling plants and before powdery mildew reached

its peak severity.

<sup>2</sup>Powdery mildew scored on a plot basis (2 to 32 plots per line) on a scale of

0 to 9 where 9 = 100% of visible mature leaf area covered with mildew.

TABLE 2. Distribution of sugarbeet plants for reaction to powdery mildew in test cross and S<sub>1</sub> families derived from WB97 and WB242 sources of resistance and (<sup>2</sup> tests for goodness of fit to 1R:1S and 3R:1S ratios, respectively.

Family No.	Testcross (1:1)				S <sub>1</sub> (3:1)			
	R	S	( <sup>2</sup>	P	R	S	( <sup>2</sup>	P
6201 = C37 x P403 (WB97)								
- 1	24	29	0.47	.10 - .50				
- 4	20	29	1.65	.10 - .50				
- 6	29	23	0.69	.10 - .50				
-11	14	29	5.23	.01 - .05*				
-22	20	14	1.06	.10 - .50				
-23	14	8	1.64	.10 - .50				
-24	7	3	1.60	.10 - .50				
Total			12.34					
Pooled	128	135	0.24	.50 - .90				
Heterogeneity			12.10	.05 - .10				

Family No.	Testcross (1:1)				S <sub>1</sub> (3:1)			
	R	S	( <sup>2</sup>	P	R	S	( <sup>2</sup>	P
6205 = C37 x P404 (WB242)								
-31	20	18	0.11	.50 - .90				
-32	20	18	0.11	.50 - .90				
-33	27	24	0.18	.50 - .90				
-34	11	10	0.05	.50 - .90				
-35	27	17	2.27	.10 - .50				
-36	16	25	1.98	.10 - .50				
-37	14	16	0.13	.50 - .90				
-38	31	26	0.44	.50 - .90				
-39	26	27	0.02	.50 - .90				
-41	15	7	2.91	.05 - .10				
-42	11	12	0.04	.50 - .90				
-43	3	6	1.00	.10 - .50				
-45	16	11	0.93	.10 - .50				
-46	21	22	0.02	.50 - .90				
-47	21	19	0.10	.50 - .90				
-48	35	12	11.26	.001***				
-49	13	10	0.39	.50 - .90				
-51	25	29	0.30	.50 - .90				
Total			22.24					
Pooled	352	309	2.80	.05 - .10				
Heterogeneity			19.44	.10 - .50				

Table 2. (cont.)

Family No.	Testcross (1:1)				S <sub>1</sub> (3:1)			
	R	S	$\chi^2$	P	R	S	$\chi^2$	P
6211 = C918aa x P402 (WB97,242)					6212 = P402⊗			
- 62	3	6	1.00	.10 - .50	11	2	0.43	.50 - .90
- 65	12	13	0.04	.50 - .90	--	--		
- 70	15	8	2.13	.10 - .50	16	6	0.06	.50 - .90
- 74	11	12	0.04	.50 - .90	--	--		
- 84	5	9	1.14	.10 - .50	--	--		
- 87	7	4	0.82	.10 - .50	6	3	0.33	.50 - .90
- 93	12	11	0.04	.90 - .95	--	--		
- 94	4	17	8.05	.001- .01**	--	--		
- 95	9	10	0.05	.50 - .90	--	--		
-101	12	14	0.15	.50 - .90	--	--		
-104	7	3	1.60	.10 - .50	--	--		
-105	4	5	0.11	.50 - .90	--	--		
-222	--	--			20	4	0.89	.10 - .50
-224	--	--			20	2	2.97	.05 - .10
-226	--	--			20	5	0.33	.50 - .90
-228	--	--			22	2	3.56	.05 - .10
-229	--	--			19	7	0.05	.50 - .90
-240	--	--			23	5	0.76	.10 - .50
Total			15.17				9.38	
Pooled	41	39	0.05	.50 - .90	151	33	4.88	.01 - .05*
Heterogeneity			15.12	.10 - .50			4.50	.50 - .90

Testcross and S<sub>1</sub> with same family number are corresponding. Each plant of P402 was selfed and crossed to susceptible tester C918. P402 segregated for S<sup>s</sup>S<sup>s</sup>:S<sup>f</sup>, thus some S<sub>1</sub> lines could not be made. In addition, supplemental plants were selfed.

Family No.	Testcross (1:1)				S <sub>1</sub> (3:1)			
	R	S	$\chi^2$	P	R	S	$\chi^2$	P
6221 = C309aa x P405 (WB97,242)					6222 = P405⊗			
-115	10	13	0.39	.50 - .90	12	8	2.40	.10 - .50
-120	12	14	0.15	.50 - .90	16	5	0.0158	.90
-201	--	--			10	3	0.26	.50 - .90
-205	--	--			25	5	1.11	.10 - .50
-212	--	--			20	5	0.33	.50 - .90
-214	--	--			10	2	0.44	.50 - .90
6223 = P405aa x C309								
-124	10	6	1.00	.10 - .50	--	--		
6225 = C309CMS x P405					6226 = P405⊗			
-136	16	11	0.93	.10 - .50	24	0	8.00	.001- .01***
Total			2.47				12.55	
Pooled	48	44	0.17	.50 - .90	117	28	2.50	.10 - .50
Heterogeneity			2.30	.50 - .90			10.05	.10 - .50



TABLE 3. Distribution of sugarbeet plants for reaction to powdery mildew in test cross and S<sub>1</sub> families that did not appear to segregate for resistance.

Family No.	Testcross		S <sub>1</sub>	
	R	S	R	S
<u>6201 = C37 x P403 (WB97)</u>				
8 families combined	9	357		
<u>6211 = C918 x P402 (WB97,242)</u>				
9 families combined	4	173	--	--
8 families combined	--	--	14	165
- 63	0	12	0	13
- 66	0	24	0	9
- 67	0	13	0	12
- 69	0	14	0	24
- 71	5	20	0	22
- 73	0	23	0	26
- 75	0	12	0	25
- 76	0	10	0	21
- 85	0	16	0	10
<u>6221 = C309 x P405 (WB97,242)</u>				
8 families combined	0	188	--	--
10 families combined	--	--	1	188
-111	0	25	0	18
-112	0	24	0	24
-116	0	23	0	21
-117	0	25	0	23
-118	0	22	5	15
<u>6225 = C309CMS x P405 (WB97,242)</u>				
-132	0	21	0	23
-133	0	20	0	14
-134	0	17	0	19
-135	0	24	0	20
-137	1	23	0	21
-142	1	23	0	8

# INDEX OF VARIETY TRIALS, SALINAS, CA, 1996-97 AT THE U.S. AGRICULTURAL RESEARCH STATION

Tests were located in five fields at Salinas and established at seven planting dates. All tests were under rhizomania infested conditions. Tests in Block 4 were supposed to be under nonrhizomania conditions, but moderate rhizomania also occurred in this field. Nortron, Pyramin, and Betamix were applied for weed control. Bayleton at 2lbs material/acre was used for powdery mildew control. Ridomyl was used to slow the spread of downey mildew. Lorsban-4E was applied for insect control. The specific planting and harvest dates as well as plot size and design are shown on each test summary.

Tests are listed in the main table of contents for Salinas by types of material and evaluation. As an aid to find test summaries, they are listed below by ascending test (planting date) number and cross- referenced to the page number. Tests shown as N/A are not available or included in this report.

TEST NO.	NO. ENTRIES	TEST DESCRIPTION	PAGE NO.
<b><u>BOLTING EVALUATION TESTS, BLOCK 2N, PLANTED NOVEMBER, 1996</u></b>			
197	128	Bolting evaluation of MM lines	A112
297	64	Bolting evaluation of mm lines	A118
397	112	Bolting evaluation of hybrids	A123
497	115	Bolting/yield evaluation of mm, S <sub>1</sub> lines	N/A
597	159	Bolting/yield evaluation of MM, S <sub>1</sub> <sup>f</sup> , S <sub>1</sub> lines	N/A
697	137	Bolting/yield evaluation of MM, S <sub>1</sub> <sup>f</sup> , Aa, S <sub>1</sub> lines	N/A
797	57	Bolting evaluation, NB selection of lines	A121
<b><u>ERWINIA ROOT ROT/POWDERY MILDEW EVAL., BLOCK 4, PLANTED MARCH 1997</u></b>			
1197	212	Inheritance of powdery mildew resistance	N/A
1297	48	Coded powdery mildew evaluation	N/A
1397	160	ERR/PM evaluation of lines	A128
1497	100	ERR/PM evaluation of hybrids	A135
<b><u>VIRUS YELLOWS (CAPITATUM RED) EVAL., BLOCK 4, PLANTED APRIL 1997</u></b>			
1597	48	VY evaluation of lines	A47
1697	24	VY evaluation of hybrids	A68
<b><u>YIELD TRIALS (MODERATE RHIZOMANIA), BLOCK 4, PLANTED APRIL 1997</u></b>			
1797	12	Monogerm conversions from multigerms	A57
1897	48	Lines and populations	A44
1997	24	Non-VY inoculated hybrids	A61
2097	24	Monogerm lines and populations	A59
2197	48	Experimental hybrids	A62
2297	48	Topcross hybrids with S <sub>1</sub> progeny	A65
<b><u>YIELD TRIALS (SEVERE RHIZOMANIA), BLOCK 2S, PLANTED MAY 1997</u></b>			
3197	16	Observation test for NR, PMR, Rz	N/A
3297	16	Evaluation of advanced progeny lines	A54
3397	16	Monogerm populations, sources of resistance	A60
3497	16	Monogerm populations	A58
3597	32	Western Sugar, BTS, & USDA hybrids	A76
<b><u>YIELD TRIALS (SEVERE RHIZOMANIA), BLOCK 2S, PLANTED MAY 1997 (cont.)</u></b>			
3697	24	BTS transgenic trial	N/A
3797	32	Topcross hybrids with S <sub>1</sub> progeny	A70
3897	64	CBGA coded rhizomania	A80
3997	64	Experimental hybrids	A72
4097	64	Lines and populations	A50
4197	8	BNYVV titer over 3 harvest dates	A154

TEST NO.	NO. ENTRIES	TEST DESCRIPTION	PAGE NO.
<b><u>RHIZOMANIA EVAL. &amp; SELECTION, BLOCK 2S, PLANTED MAY 1997</u></b>			
5097	12	Evaluation & selection for resistance	N/A
5197	44	Eval. & selection for Rz, ERR, PMR	N/A
5297	48	Rz/yield evaluation of mm S <sub>1</sub> lines	N/A
5397	160	Rz/yield evaluation of MM, S <sub>1</sub> <sup>+</sup> S <sub>1</sub> lines	N/A
5497	144	Rz/yield evaluation of MM, S <sub>1</sub> <sup>f</sup> , Aa S <sub>1</sub> lines	N/A
5597	56	Eval./selection for combined Rz/PMR	N/A
5697	36	Eval. Of East Lansing/Fort Collins lines	A155
5797	32	Eval. Of Plant Introductions (PI's)	A139
5897	12	Eval./selection for Rz	N/A
5997	96	Evaluation of breeding lines	N/A
<b><u>RHIZOMANIA EVAL. &amp; SELECTION, BLOCK 2S, PLANTED JUNE 1997</u></b>			
6097	24	Replant of WS, BTS, & USDA hybrids	A78
6197	144	Evaluation of progeny lines	N/A
<b><u>RHIZOMANIA RESISTANCE SELECTION, BLOCK 2S, PLANTED AUGUST 1997</u></b>			
7197	400	Selection for Rz from 1997 seed lots	N/A
<b><u>CHICORY EVALUATION, BLOCKS 4 &amp; 2S, PLANTED MARCH &amp; MAY 1997</u></b>			
C197	12	Eval. of cultivars	N/A
C297	24	Eval. of breeding lines	N/A
C397	16	Eval. of cultivars	N/A
C497	16	Eval. of breeding lines	N/A
<b><u>IMPERIAL VALLEY TRIALS, BRAWLEY, CA.</u></b>			
<b><u>NON RHIZOMANIA YIELD, FIELD J, PLANTED SEPTEMBER 1996</u></b>			
B197	32	Experimental hybrids	A84
B297	32	Area 5 Coded yield test	A91
B397	48	Topcross hybrids with S <sub>1</sub> progeny	A86
B497	24	Population hybrids	A89
<b><u>RHIZOMANIA YIELD (MILD DISEASE), FIELD K, PLANTED SEPTEMBER 1996</u></b>			
B597	32	Experimental hybrids	A95
B697	32	Area 5 Rhizomania Coded test	A99
B797	16	Population hybrids	A97
<b><u>SEVERE RHIZOMANIA (LATE HARVEST), FIELD K, PLANTED SEPTEMBER 1996</u></b>			
B897	48	Lines under severe rhizomania	A103
B997	30	Area 5 Rhizomania Coded	A105
B1097	12	Hybrids	
<b><u>CHICORY, FIELD J, PLANTED SEPTEMBER 1996</u></b>			
Chicory	6	Evaluation of cultivars	N/A
<b><u>BSDF CURLY TOP NURSERY, KIMBERLY, ID., 1997</u></b>			
USDA	180	Curly Top evaluation	A107
<b><u>VIRUS YELLOWS EVALUATION, DAVIS, CA</u></b>			
196	12	Evaluation of hybrids, 1996	A143
197	12	Evaluation of hybrids, 1997	N/A

TEST 1897. PERFORMANCE OF LINES UNDER NON-CRV INOCULATED CONDITIONS, SALINAS, CA., 1997

48 entries x 8 reps., RCB(E); 3 subtests: 16V x 8R, RCB(E)  
1-row plots, 21 ft. long

Planted: April 10, 1997  
Harvested: September 30, 1997

Variety	Description	Acre Yield		Beets/ 100'	Sucrose %	Root		Powdery Mildew
		Sugar	Beets			Rot	RJAP	
		Lbs	Tons			%	%	
<u>1897-1: MM,O.P. LINES, 16V x 8R, RCB(E)</u>								
B4454	Betaseed, 4454.6382, 2-20-97	9423	38.20	188	12.39	0.0	81.4	7.0
KW6770	KWS 6770.5193, 1-10-97	8099	31.95	170	12.66	0.5	81.0	7.0
F86-31/6	Inc. C31/6 (L86263)	7720	30.00	155	12.86	0.0	82.6	6.5
R681(C82)	NB-RZM R481-43,-89; R482NB,R484	11488	40.80	183	14.09	0.0	80.6	7.1
R576-89-18	RZM R476-89-18 (C76-89-18)	10504	37.60	167	13.98	0.0	81.2	7.8
R576-89-5	RZM R476-89-5 (C76-89-5)	10448	35.10	192	14.88	0.0	79.5	7.0
268	Inc. 768(US75), susc.ck.	6351	29.20	177	10.85	0.0	79.2	8.1
Y668	RZM Y568	10243	38.10	178	13.41	0.0	81.1	7.6
Y669	RZM Y569, F2(Y#C2 x Y462 & 3)	11239	40.05	176	14.02	0.0	81.5	6.3
Y635	RZM R535, F2(C37*3xRima) (C79-7)	9315	33.28	192	14.01	0.0	80.1	8.5
R678(Iso)	NB-RZM R478NB (C78)	11282	39.05	177	14.49	0.0	80.9	7.8
R678/2	RZM R578/2 (C78/2)	11206	38.60	189	14.53	0.0	80.0	7.8
R680NB	NB-RZM R480NB (C80NB)	11158	39.50	179	14.14	0.0	79.6	8.0
R680-#	NB-RZM R480-#,-45 (C80)	11324	38.05	178	14.88	0.0	81.6	7.0
R639	RZM R539 (C39R)	10561	39.59	164	13.36	0.0	79.5	5.4
R647	RZM R547 (C47R)	11513	39.65	191	14.53	0.0	82.0	7.3
Mean		10117.1	36.80	178.5	13.69	0.0	80.7	7.3
LSD (.05)		777.5	2.86	17.3	0.53	0.3	1.8	0.7
C.V. (%)		7.7	7.84	9.8	3.88	1128.7	2.2	10.2
F value		30.9**	13.24**	3.0**	32.51**	1.0NS	2.5*	9.0**

TEST 1897. PERFORMANCE OF LINES UNDER NON INOCULATED CONDITIONS, SALINAS, CA., 1997  
48 entries x 8 reps., RCB(E). ANOVA to compare means across sets of entries.

Mean	10350.5	37.55	13.74	181.5	0.0	80.4	7.2
LSD (.05)	811.9	2.80	0.52	19.7	0.3	2.1	0.8
C.V. (%)	8.0	7.56	3.86	11.0	814.6	2.7	10.5
F value	29.0**	18.92**	16.37**	2.0**	0.9NS	1.9**	15.3**

Test 1897 is Non-CRV (VY) inoculated companion test of Test 1597.

TEST 1897. PERFORMANCE OF LINES UNDER NON INOCULATED CONDITIONS, SALINAS, CA., 1997

(cont.)

Variety	Description	Acre Yield		Beets/ 100'	Sucrose %	Root		Powdery Mildew Score
		Sugar	Beets			Rot	RJAP	
		Lbs	Tons	No.	%	%	%	
1897-2: MM,O.P. LINES WITH WILD BEET GERMP LASM, 16V x 8R, RCB(E)								
R522 (Sp)	RZM-%S R22F & R22Y(C) , (C51)	9852	36.00	184	13.71	0.3	78.6	7.5
R322Y3%	YR-ER-PMR R122Y2 (%S)	9622	33.98	162	14.13	0.0	80.7	7.3
664	RZM Y564R, F3 (C37,C82,C78,C80xR22Y)	10709	37.90	182	14.11	0.0	81.0	7.1
Y665	RZM Y565, F2 (C80,C82 x [C37,R81-89 x (C37 x R22)] )	10838	39.65	180	13.68	0.0	79.0	8.3
Y666	RZM Y566, F2 (Y#C1 x Y64)	11194	40.40	179	13.87	0.0	80.4	7.5
Y667	RZM Y567, F2 (Y#C2 x Y64)	11010	39.70	169	13.87	0.0	81.9	6.6
Y671	RZM 5205,P;... ,F2 (C37,C82,C78,C80xY64)	10403	38.20	186	13.62	0.0	80.4	8.1
Y672	RZM 5280,P;84,P,F2 (C80,C82 x Y65)	12167	42.65	183	14.27	0.0	80.7	6.9
B4776R	Betaseed, 4776.6102, 2-20-97	13575	45.70	193	14.86	0.0	81.6	3.5
U86-37	Inc. C37, L86443	5979	23.45	168	12.77	0.0	80.7	8.0
R646	RZM R546,BC3F3 (C37*3xR22)	9008	32.75	189	13.82	0.0	80.2	8.4
R643	RZM-%S R443, F2[R81-89x (C37xR22)]	11116	39.60	194	14.03	0.0	79.5	8.6
R651	RZM R551, F2 (C37*2xC79-#s)	8447	31.50	189	13.40	0.4	80.0	8.3
Rival	HH103, 8-29-95	11530	39.80	185	14.50	0.0	80.5	8.4
P604	PMR P404, F3 (C37*4xWB242)	9688	35.85	192	13.50	0.0	79.5	4.0
R626	RZM R526, F3 (C37xPI Bvm-UK)	8548	32.45	184	13.14	0.0	77.4	8.8
Mean		10230.5	36.85	182.5	13.83	0.0	80.1	7.3
LSD (.05)		876.6	2.83	18.3	0.53	0.3	2.3	0.7
C.V. (%)		8.7	7.76	10.1	3.87	812.1	2.9	9.0
F value		31.3**	27.00**	4.9*	7.24**	0.9NS	2.0*	43.4**

Notes: See Tests 1597 (CRV inoculated) and 4097 (rhizomania). Test 1897 was grown under moderate rhizomania. C69 was selected from Y669. C67 was selected from Y667. C72 was selected from Y672. P604 segregates for PMR from WB242.

TEST 1897. PERFORMANCE OF LINES UNDER NON INOCULATED CONDITIONS, SALINAS, CA., 1997

(cont.)

Variety	Description	Acre Yield		Beets/ 100'	Root Rot	RJAP	Powdery Mildew
		Sugar	Beets				
		Lbs	Tons	No.	%	%	Score
1897-3: MM,Sf,Aa POPULATIONS, 16V x 8R, RCB(E)							
R609R2	CR-RZM R409R2 (CR09)	10559	38.40	185	0.0	80.0	7.1
R610R2	CR-RZM R410R2 (CR10)	10698	38.64	180	0.0	80.7	6.9
6925	YR S1(C) 4909-#,4915-#,4918-#						
		10337	38.10	172	0.0	79.6	7.0
6931	5915,5925,S1(C)aa x 931(C)A	13242	46.50	190	0.0	81.9	6.6
6924	RZM 5925,F2(RZM 4918aa x Y#(C)	11430	42.55	179	0.0	79.7	6.1
6929	RZM R581H11,18;R576-89-18H18,19,9;5211,12						
		11876	41.25	171	0.0	81.8	6.4
6930	RZM R578H11,16,19,18	12157	43.10	183	0.0	80.1	6.6
6927	RZM 5921H18,F2[918aa x (915xR22)]	11495	41.25	180	0.0	79.7	7.4
6921H25	5925aa x RZM-8S R21(C),F1[(925aa(915xR22)]						
		11425	40.20	178	0.0	80.2	7.4
5911-4M	RZM 4911-4Maa x A (C911-4)	12177	42.53	171	0.0	79.6	6.4
6913-70 (Sp)	5913-70aa x A, (C913-70)	10292	36.35	201	0.0	78.6	8.0
N621	NR-RZM N521, N522	10153	38.25	184	0.3	79.8	6.4
monogerm,Sf,Aa POPULATIONS							
6808	C790mmaa x 808(C)	7412	30.85	185	0.3	80.9	7.6
6890	RZM 5890,C890-1(Rz)	9451	36.10	180	0.0	79.9	7.9
6869 (Sp)	5869mmaa x A	9426	35.35	205	0.2	81.7	8.0
6835H69	5869mmaa x 835(C)	9132	34.85	190	0.0	81.6	8.3
Mean		10703.8	39.02	183.4	0.1	80.4	7.1
LSD (.05)		802.5	2.83	18.1	0.3	2.4	0.7
C.V. (%)		7.6	7.32	9.9	657.8	3.0	10.5
F value		25.1**	14.64**	2.2*	0.9NS	1.3NS	6.6**

TEST 1597. PERFORMANCE OF LINES UNDER CRV (CAPITATUM RED LUTEOVIRUS) INFECTION, SALINAS, CA., 1997

48 entries x 8 reps., RCB(E)

3 subtests, 16 entries x 8 reps, RCB(E)

1-row plots, 21 ft. long

Planted: April 10, 1997

Harvested: October 7, 1997

Inoculated CRV: June 10, 1997

Variety	Description	Acre Yield			Beets/ 100'	Sucrose %	No.	RJAP %	Powdery		
		Sugar Lbs	Loss %	Beets Tons					Score	Mildew	CRV
1597-1: MM,O.P. LINES, 16V x 8R, RCB(E)											
B4454	Betaseed, 4454.6382, 2-20-97	7078	25	29.30	12.12	170	82.3		6.8	4.4	
KW6770	KWS 6770.5193, 1-10-97	5632	30	24.05	11.71	183	81.6		7.1	4.8	
F86-31/6	Inc. C31/6 (L86263)	6662	14	26.85	12.41	155	80.3		6.5	3.0	
R681(C82)	NB-RZM R481-43,-89;R482NB,R484	9049	21	33.50	13.49	168	77.6		6.4	3.2	
R576-89-18	RZM R476-89-18	9249	12	33.25	13.91	164	81.3		6.9	3.0	
R576-89-5	RZM R476-89-5	9480	9	31.60	15.01	156	80.9		5.6	2.6	
268	Inc. 768(US75), susc.check	4439	30	22.60	9.77	182	74.7		7.8	5.4	
Y668	RZM Y568,F <sub>2</sub> (Y#C1 x Y462 & 3)	7932	23	31.21	12.68	165	78.7		6.9	3.4	
Y669	RZM Y569,F <sub>2</sub> (Y#C2 x Y462 & 3)	10207	9	36.65	13.96	177	80.9		5.9	3.4	
R635	RZM R535(gh), F <sub>2</sub> (C37*3 x Rima)	7595	18	28.30	13.44	178	79.2		7.5	3.3	
R678(Iso)	NB-RZM R478NB (C78)	8601	24	30.53	14.11	174	79.2		7.4	4.3	
R678/2	RZM R578/2 (C78/2)	9836	12	34.63	14.22	167	80.7		6.5	2.9	
R680NB	NB-RZM R480NB (C80NB)	8706	22	31.70	13.72	157	78.3		6.9	3.1	
R680-#	NB-RZM R480-#,-45 (C80)	9495	16	33.80	14.02	169	79.3		6.4	2.8	
R639	RZM R539 (C39R)	9376	11	36.40	12.89	174	79.7		5.6	3.9	
R647	RZM R547 (C47R)	8311	28	29.75	13.96	178	80.7		6.4	3.6	
Mean		8288.1	18	30.9	13.21	169.7	79.7		6.6	3.6	
LSD (.05)		846.6		3.0	0.52	21.6	2.2		0.6	0.5	
C.V. (%)		10.4		9.7	4.00	12.9	2.7		8.6	13.3	
F value		28.0**		14.5**	46.80**	1.4NS	5.8**		9.6**	22.5**	

TEST 1597. PERFORMANCE OF LINES UNDER CRV (CAPITATUM RED LUTEOVIRUS) INFECTION, SALINAS, CA., 1997

48 entries x 8 replications, RCB(E). ANOVA to compare means across sets of entries.

Mean	8488.2	31.79	13.27	174.2	79.4	6.7	3.6
LSD (.05)	807.5	2.73	0.51	21.6	2.1	0.5	0.5
C.V. (%)	9.7	8.71	3.94	12.6	2.7	7.9	13.3
F value	28.6**	20.59**	24.25**	2.2**	3.3**	11.8**	17.5**

Test 1597 is CRV inoculated companion test of Test 1897. Estimated % loss for sugar yield is the difference between these two tests where %loss = [(Noninoc.- CRV inoc.)/Noninoc.]100.

TEST 1597. PERFORMANCE OF LINES UNDER CRV (CAPITATUM RED LUTEOVIRUS) INFECTION, SALINAS, CA., 1997

(cont.)

Variety	Description	Acre Yield			Beets/ 100'	RJAP %	Powdery Mildew		CRV
		Sugar	Loss	Beets			Score	Mean	
		Lbs	%	Tons					
1597-2: MM,O.P. LINES WITH WILD BEET GERMPLASM, 16V x 8R, RCB(E)									
R522(sp)	RZM-%S R22R & R22Y(C), (C51)	8068	18	31.10	12.97	77.0	7.1	4.1	
R322Y3%	YR-ER-PMR R122Y2 (%S)	8571	11	30.25	14.17	80.0	6.8	3.1	
Y664	RZM Y564R,F <sub>3</sub> (C37,C82,C80 x R22Y)	8814	18	32.40	13.57	79.2	7.1	3.2	
Y665	RZM Y565,F <sub>2</sub> {C80,C82 x [C37,R81-89 x (C37 x R22)]}	9379	13	35.20	13.33	78.6	6.9	3.3	
Y666	RZM Y566, F <sub>2</sub> (Y#C1 x Y64)	9127	18	34.05	13.39	79.2	6.9	3.5	
Y667	RZM Y567, F <sub>2</sub> (Y#C2 x Y64)	9666	12	35.40	13.68	80.5	5.9	3.0	
Y671	RZM 5205,P;...F <sub>2</sub> (C37,C82,C80xY64)	9352	10	35.00	13.36	80.1	6.9	3.1	
Y672	RZM 5280,P;84,P,F <sub>2</sub> (C80,C82 x Y65)	10304	15	38.15	13.52	79.2	6.4	3.1	
B4776R	Betaseed, 4776.6102,2-20-97	10365	24	35.90	14.45	81.4	5.1	5.3	
U86-37	Inc. C37, L866443	5339	11	21.40	12.46	78.3	7.3	3.4	
R646	RZM R546, BC <sub>3</sub> F <sub>3</sub> (C37*3 x R22)	7426	18	28.55	13.00	78.2	6.8	3.4	
R643	RZM-%S R443, F <sub>2</sub> (R81-89 x (C37xR22)]	9341	16	33.65	13.88	78.6	7.4	3.3	
R651	RZM R551, F <sub>2</sub> (C37*2 x C79-#s)	7052	17	27.52	12.86	78.7	7.4	3.3	
Rival	HH103, 8-29-95	7721	33	27.55	13.99	80.2	7.6	4.8	
P604	PMR P404, F <sub>3</sub> (C37*4 x WB242)	7685	21	29.10	13.22	80.2	5.3	3.4	
R626	RZM R526, F <sub>3</sub> (C37 x PI Bvm-UK)	7202	16	28.15	12.77	77.0	7.6	3.1	
Mean		8463.2	17	31.46	13.41	79.2	6.8	3.5	
LSD (.05)		773.3		2.55	0.44	21.6	0.5	0.5	
C.V. (%)		9.2		8.19	3.30	12.5	7.7	13.0	
F value		23.7**		22.31**	11.92**	2.8**	3.1**	17.2**	
								15.5**	

Test 1597 was grown under moderate rhizomania. Thus performance is influenced by variety performance and reaction to both CRV and rhizomania. See Test 1897 for additional information on line description and identification. CRV was scored on a scale of 0-9 where 9 = 100% yellowed canopy.



(cont.)

Variety	Description	Acre Yield			Beets/ 100'	RJAP	Powdery		CRV	
		Sugar	Loss	Beets			Sucrose	Mildew		CRV
		Lbs	%	Tons						
1597-3: MM,S <sup>f</sup> ,Aa POPULATIONS, 16V x 8R, RCB(E)										
R609R2	CR-RZM R409R2 (CR09)	8294	21	31.45	13.17	173	79.2	7.1	3.9	
R610R2	CR-RZM R410R2 (CR10)	8414	21	31.85	13.23	178	79.5	7.0	4.4	
6925 <sup>2</sup>	YR S <sub>1</sub> (C)4909-#,4915-#,4918-#	9165	11	33.90	13.54	166	78.5	6.9	3.1	
6931 <sup>3</sup>	5915,5925,S <sub>1</sub> (C)aa x 931(C)A	11301	15	41.10	13.76	181	79.1	6.5	3.4	
6924 <sup>4</sup>	RZM 5924,F <sub>2</sub> (RZM 4918aa x Y#(C))	9429	18	35.05	13.46	161	80.5	6.1	3.6	
6929 <sup>4</sup>	RZM R581H11,18;R576-89-18H18	10633	10	37.85	14.04	174	80.2	5.9	3.2	
6930 <sup>4</sup>	RZM R578H11,16,19,18	9735	20	35.15	13.83	171	79.6	6.5	3.8	
6927 <sup>5</sup>	RZM 5921H18,F <sub>2</sub> [918aa x (915 x R22)]	9568	17	36.30	13.16	168	78.1	6.8	3.3	
6921H25 <sup>5</sup>	5925aa x RZM-%S R21(C)	10151	11	36.70	13.84	193	78.8	6.9	3.6	
5911-4M	RZM 4911-4Maa x A (C911-4)	10163	17	36.25	14.04	176	78.5	6.3	3.1	
6913-70	5913-70aa x A, (C913-70)	9880	4	35.70	13.83	201	77.8	6.8	2.9	
N621	NR-RZM N521,N522	8861	13	34.60	12.79	178	80.2	6.3	3.3	
monogerm,S <sup>f</sup> ,Aa POPULATIONS										
6808	C790mmaa x 808(C)	5972	19	26.00	11.43	168	78.6	7.6	4.9	
6890	RZM 5890, C890-1 (Rz)	6891	27	27.07	12.72	185	80.4	7.1	3.9	
6869(sp)	5869mmaa x A	6202	34	24.60	12.63	199	80.3	7.8	5.0	
6835H69	5869mmaa x 835(C)	5713	37	24.90	11.45	178	78.0	7.9	5.1	
Mean		8773.2	18	33.03	13.18	178.2	79.2	6.8	3.8	
LSD (.05)		830.1		2.78	0.53	20.0	2.3	0.5	0.5	
C.V. (%)		9.6		8.50	4.09	11.3	3.0	7.2	13.8	
F value		34.0**		24.88**	18.43**	2.6*	1.2NS	11.4**	14.9**	

<sup>2</sup>6925 = Recombined S<sub>1</sub> progeny of S<sub>1</sub> line composite selected for VYR at Davis in 1995.<sup>3</sup>Recombined S<sub>1</sub> progeny.<sup>4</sup>= MM,S<sup>f</sup>,aa x MM, open-pollinated to create new popns.<sup>5</sup>Backcross lines to transfer R22 resistance to MM,S<sup>f</sup>,A:aa popns.

TEST 4097. RHIZOMANIA EVALUATION OF LINES, BLOCK 2S, SALINAS, CA., 1997

64 entries x 8 reps., RCB(E); 4 subtests, 16 entries x 8 reps., RCB(E)

1-row plots, 20 ft. long

Planted: May 2, 1997  
Harvested: October 14, 1997

Variety	Description	Acre Yield		Beets/ 100'	Bolting %	Root Rot %	RJAP %	Powdery	
		Sugar	Beets					Score	Mildew
		Lbs	Tons						
Test 4097-1: MM,O.P. LINES, 16V x 8R, RCB(E)									
US H11	113102, 3-18-97	4152	18.15	11.35	0.0	0.3	80.6	8.5	
Rrizor	SES, F291, 2-13-96	7398	23.78	15.59	0.0	0.4	78.6	8.5	
R639	RZM R539, C39R	7796	28.17	13.90	0.0	1.0	81.5	6.4	
R647	RZM R547, C47R	6843	23.89	14.35	0.0	1.8	82.4	7.5	
U86-46/2	Inc. C46/2, 86342	5163	19.29	13.29	0.0	2.2	79.2	7.8	
R678(Iso)	NB-RZM R478NB, C78	6365	21.72	14.65	0.0	2.5	81.6	8.5	
R678/2	RZM R578/2, C78/2	6884	24.00	14.34	0.0	1.8	80.6	8.1	
Y954	Inc. Y854, C54	4917	19.23	12.74	0.0	0.8	82.1	7.8	
R680(Iso)	RZM R580, C80	7392	27.09	13.68	0.0	1.3	79.9	7.1	
R680NB(Iso)	NB-RZM R480NB, C80NB	6239	22.21	14.05	0.0	1.5	79.7	7.8	
R680-#	NB-RZM R480-45,-#, (C80-45)	6713	22.54	14.89	0.0	0.7	81.0	7.1	
R681	NB-RZM R481-43,-89;R482, (C82)	6538	23.13	14.14	0.0	0.0	80.3	7.6	
Y662	RZM Y562R	7763	27.90	13.91	0.0	0.7	81.1	7.4	
Y663	RZM Y563R	7337	27.47	13.43	0.0	2.5	81.7	7.5	
Y668	RZM Y568	6282	23.40	13.43	0.0	1.7	82.6	7.9	
Y669	RZM Y569, (~C69)	6811	25.08	13.56	0.0	3.7	80.8	6.6	
Mean		6537.1	23.57	13.83	0.0	1.4	80.9	7.6	
LSD (.05)		714.2	2.50	0.74		3.1	3.2	0.7	
C.V. (%)		11.0	10.71	5.44		220.0	123.7	8.9	
F value		16.3**	11.98**	12.85**		0.8NS	1.0NS	6.8**	

TEST 4097. RHIZOMANIA EVALUATION OF LINES, BLOCK 2S, SALINAS, CA., 1997

64 entries x 8 reps., RCB(E). ANOVA to compare means across sets.

Mean	6590.2	24.19	13.57	177.8	0.2	1.2	80.3	7.6
LSD (.05)	720.8	2.50	0.76	17.5	0.8	3.0	3.3	0.7
C.V. (%)	11.1	10.47	5.66	10.0	381.0	264.1	4.1	9.2
F value	19.6**	14.21**	7.99**	6.3**	18.6**	1.1NS	1.1N	13.15**

Also see Tests 1597 & 1897.

(cont.)

Variety	Description	Acre Yield		Sucrose %	Beets/ 100'	Bolting %	Root		RJAP %	Powdery Mildew	
		Sugar Lbs	Beets Tons				Rot %	Score			
Test 4097-2: MM,O.P. LINES with R22, 16V x 8R, RCB(E)											
R626	RZM R526 (C37 x PI-Bvm-UK)	5267	20.26	13.02	184	0.0	0.7		78.4		8.4
R522 (sp)	RZM-½ S R22(C) , (C51)	7468	27.58	13.57	174	0.0	0.8		78.8		8.3
Y673	U86-37rr x Y71 (C)	5638	21.02	13.46	166	0.0	0.3		80.2		7.5
Y664	RZM Y564R	7386	26.65	13.88	184	0.0	1.4		79.1		7.6
Y665	RZM Y565	7528	27.18	13.85	173	0.0	0.0		80.5		7.9
Y666	RZM Y566	6771	24.22	13.98	185	0.0	3.5		82.6		7.8
Y667	RZM Y567, (~C67)	7389	26.71	13.89	182	0.0	0.3		80.7		6.3
Y671 (Iso)	RZM 5205,P;5206,P;...	7044	26.27	13.41	179	0.0	4.8		78.4		7.1
Y671 (sp)	RZM 5205,P;5206,P;...	7632	28.12	13.57	183	0.0	0.3		79.8		7.6
Y672	RZM 5280,P;5284,P, (~C72)	7681	28.17	13.65	181	0.0	0.0		79.1		7.4
R643	RZM-½ S R443	7476	26.82	13.93	192	0.0	0.9		78.8		8.5
B4776R	Betaseed, 6102, 2-20-97	9252	31.10	14.89	200	0.0	0.7		80.2		3.4
6921 (sp)	RZM-½ S R21 (C)	8305	29.69	14.01	186	0.0	0.0		82.4		7.6
6921H25	5925aa x RZM-½ S R21 (C)	7666	27.85	13.77	174	0.0	2.5		79.7		8.4
6926	RZM 5287,P	6503	23.08	14.05	179	0.0	1.9		79.3		7.4
6927	RZM 5921H18	7935	28.06	14.11	175	0.0	0.0		80.4		7.6
Mean		7308.9	26.42	13.82	180.9	0.0	1.1		79.9		7.4
LSD (.05)		819.6	2.76	0.72	17.2		3.5		2.9		0.7
C.V. (%)		11.3	10.57	5.27	9.6		311.8		3.6		9.3
F value		10.6**	8.79**	2.45**	1.8NS		1.2NS		1.5NS		15.4**

Lines in Test 4097-2 have germplasm from R22 (C50,C51), i.e., rhizomania resistance from *Beta vulgaris* spp. *maritima*.

TEST 4097. RHIZOMANIA EVALUATION OF LINES, BLOCK 2S, SALINAS, CA., 1997

(cont.)

Variety	Description	Acre Yield		Beets/ 100'	Bolting %	Root Rot %	RJAP %	Powdery Mildew Score
		Sugar	Beets					
		Lbs	Tons					
Test 4097-3: MM,O.P. LINES NEAR ISO-LINES OF C37, 16V x 8R, RCB(E)								
P603	PMR P403 (PMR from WB97)	5568	20.70	13.45	4.6	0.3	82.0	6.1
P604	PMR P404 (PMR from WB242)	6121	22.54	13.57	9.5	0.7	78.5	5.0
U86-37	Inc. C37, 86443	4027	15.76	12.79	0.0	0.0	80.5	8.1
R636	RZM R536, C79-8 (R22)	6181	23.95	12.90	0.0	0.3	79.3	8.8
R646	RZM R546, C79-8 (R22)	6387	23.89	13.40	0.0	0.4	80.1	8.1
R653	RZM 5243,P,C79-8 (R22)	5891	21.78	13.50	0.0	0.3	81.8	7.9
R679	RZM R579,C79-1 (Rz)	4798	18.80	12.74	0.0	0.7	79.1	7.6
R635	RZM R535(gh), C79-7 (SES)	5875	21.07	13.95	0.0	0.8	80.4	8.4
R645	RZM R545,R532,C79-5 (R04)	4750	19.61	12.14	0.0	1.1	77.8	8.8
R637	RZM R537,R550,C79-9 (WB151)	5215	18.69	13.90	0.0	1.1	80.2	7.5
R641	RZM R541,R548,C79-10 (WB169)	5502	21.56	12.81	0.0	0.4	80.6	8.1
R642	RZM R542,R549,C79-11 (WB258)	5642	21.29	13.26	0.0	0.9	78.8	8.0
US H11	113102, 3-18-97	3815	17.82	10.63	0.0	1.0	78.8	8.8
R651	RZM R551	5369	21.24	12.65	0.0	0.0	79.4	8.6
R640	RZM R540% (Iso)	7279	26.17	13.90	0.0	0.0	79.1	8.5
R640-1	RZM-%S R440-1, R540-1	6828	24.70	13.80	0.0	0.4	81.4	8.6
Mean		5578.1	21.22	13.09	0.9	0.5	79.9	7.9
LSD (.05)		606.3	2.10	0.82	1.6	1.3	4.0	0.7
C.V. (%)		11.0	10.01	6.35	9.6	189.2	5.0	9.0
F value		18.4**	12.97**	8.29**	2.8**	19.0**	0.7NS	26.5**

(cont.)

Variety	Description	Acre Yield		Beets/ 100'	Bolting	Root	RJAP	Powdery Mildew
		Sugar	Beets					
		Lbs	Tons					
Test 4097-4: MM,S <sup>f</sup> ,Aa POPULATIONS, 16V x 8R, RCB(E)								
Rival	HH103, 1032406,3-18-97	7493	26.06	183	0.4	0.0	80.9	8.8
6915	NB-RZM 4911,...,4918-# (C)	7774	28.01	169	0.0	1.9	79.6	6.8
6925	YR 4909-#,...,4918-# (C)	6823	25.30	170	0.0	1.5	79.8	7.1
7903	6903aa x A	4661	18.64	78	0.0	1.0	80.5	7.4
6931	5915,5925aa x 931 (C)	7319	27.68	175	0.0	1.8	80.3	7.4
6924	RZM 5924	6596	24.81	169	0.0	1.5	81.9	7.1
6929	RZM R581H11,...,5212	6623	23.40	165	0.0	0.0	80.0	7.5
6930	RZM R578H11,...,R578H18	7269	26.77	176	0.0	0.4	80.2	7.3
R678H5	Z325 (~CZ25)aa x R578	7891	26.92	186	0.0	1.4	81.7	8.0
Y671H25	5925aa x Y71 (C)	7569	27.25	179	0.0	3.8	81.6	8.0
6920	RZM 5920	6578	24.63	163	0.0	0.8	79.4	8.1
6923	RZM 5923	7166	27.14	169	0.0	3.8	79.1	7.1
P602NR	NR P202 (NR from WB242)	6362	23.84	171	0.0	3.3	82.8	7.1
R609R2	CR-RZM R409R2, CR09	6602	25.19	182	0.0	3.4	79.9	8.4
R610R2	CR-RZM R410R2, CR10	7600	27.42	175	0.0	0.0	82.7	8.3
N621	NR-RZM N521,N522	6662	25.84	188	0.0	0.7	81.2	7.4
Mean		6936.7	25.56	168.5	0.0	1.6	80.7	7.6
LSD (.05)		719.9	2.54	18.6	0.3	3.5	2.9	0.7
C.V. (%)		10.5	10.02	11.1	1116.0	224.4	3.6	8.7
F value		9.2**	6.52**	14.6**	1.0NS	1.1NS	1.3NS	6.0**

TEST 3297. RHIZOMANIA EVALUATION OF PROGENY LINES, BLOCK 2S, SALINAS, CA., 1997

16 entries x 4 replications, RCB  
1-row plots, 20 ft. long

Planted: April 30, 1997  
Harvested: October 23, 1997

Variety	Description	Acre Yield		Beets/ 100'	Sucrose %	Powdery	
		Sugar	Beets			Mildew	RJAP
		Lbs	Tons			Score	%
US H11	113102, 3-18-97	3751	17.70	163	10.57	6.8	80.7
5911-4 (Iso)	NB-ER-RZM 3911-4 (C911-4)	7659	29.40	168	13.02	4.0	77.9
6911-4-7	RZM 5911-4-7	6781	23.94	156	14.13	3.3	77.1
6911-4-7HOM	5911-4-7MCMS x RZM 5911-4-7	8491	30.87	183	13.75	3.8	76.9
6931-4	RZM T-O sel. 4831-4mm	6380	22.14	131	14.43	5.0	75.7
6911-4-10	RZM 4911-4-10M	6986	23.38	150	15.00	4.0	77.9
6915-7-6	RZM 4915-7-6	5324	19.43	154	13.67	3.8	77.5
6918-3	RZM 4918-3	7256	24.26	158	15.00	4.3	78.8
6918-12	RZM 4918-12	7352	25.18	171	14.60	3.3	79.7
6913-70 (Iso)	RZM 5913-70 (C913-70)	6917	24.57	188	14.10	5.3	80.7
R609	CR-RZM R409 (CR09)	7198	27.41	165	13.15	4.5	80.3
R610	CR-RZM R410 (CR10)	6844	25.73	151	13.30	4.3	77.9
6930	RZM R578H11, 16, 18, 19	7538	27.83	170	13.63	4.5	80.1
9903	YR-ER-PMR 7903 (rzrz)	6003	22.73	134	13.25	5.0	81.7
6859-8M	Inc. 2859mA (sp) -8M	4885	17.40	153	14.07	5.3	78.5
6891-10m	Inc. 2891mA (sp) -10mm	5314	19.02	181	14.00	5.3	80.0
Mean		6542.5	23.81	160.9	13.73	4.5	78.8
LSD (.05)		1011.5	3.69	20.9	0.86	0.9	2.8
C.V. (%)		10.9	10.87	9.1	4.37	14.4	2.5
F value		11.6**	9.61**	4.8**	11.95**	7.7**	2.9**

NOTES: Moderate to severe rhizomania. 6911-4-7 = increase of S<sub>1</sub> monogerm line selected from C911-4.  
6911-4-7HOM = development of CMS counter part to 6911-4-7 (unfortunately, we have been unable to identify and select O-type from this S<sub>1</sub> mm line). 6931-4 = increase of S<sub>1</sub> mm, O-T line from cross C911-4mmaa x mm, O-T. 6911-4-10, 6915-7-6, 6918-3, 6918-12, 6913-70 = increases of MM, S<sub>1</sub> lines from MM, S<sub>1</sub> Aa, Rz populations. 6930 = new MM, S<sub>1</sub> Aa, Rz popn. 9903 = rzrz, MM, S<sub>1</sub> Aa population from VYR breeding program. R609 & R610 combine Rz and CR from an Italian source. 6859-8 = increase of S<sub>1</sub> line from C859; 6891-10 from C890.

TEST 5697. RHIZOMANIA EVALUATION OF FC & E.LANSING LINES, BLOCK 2S, SALINAS, CA., 1997

36 entries x 8 replications, RCB  
1-row plots, 13 ft. long

Planted: May 8, 1997  
Harvested: November 12, 1997

Variety	Description <sup>1</sup>	Acre Yield		Beets/ 100'	RJAP %	Powdery		Rhizomania %R
		Sugar	Beets			Mildew		
		Lbs	Tons			Mean	DI	
<u>Salinas entries</u>								
US H11	113102, 3-18-97	1928	10.95	186	72.7	4.6	5.3	23.4
R609R2	CR-RZM R409R2, (CR09)	5425	22.80	181	77.0	5.3	3.3	76.9
R639	RZM R539, (C39R)	5096	19.87	175	77.1	4.6	3.1	75.1
R681	NB-RZM R481,..., (C82)	5200	19.79	159	76.8	4.4	3.2	75.5
6835H11M	RZM 4911-4Maa x 835(C)	4520	19.29	164	78.1	5.0	3.9	59.5
6808m	0790mmaa x 808(C)	3056	13.16	196	78.1	5.3	4.2	49.3
5859%	RZM-%S 3859m(Sp), (C859)	3721	15.48	175	77.0	5.4	4.0	56.4
6890	RZM 5890, (C890-1)	4256	17.59	208	77.0	5.1	4.0	55.1
6869	RZM 5869mm	3622	14.94	186	77.3	5.1	3.6	66.8
<u>Ft. Collins entries</u>								
LSR	Ft. Collins LSR mix	3877	19.66	180	78.1	3.3	4.2	50.7
CTR	971012MS	4550	18.89	190	74.0	5.6	4.5	41.1
<u>E.Lansing entries</u>								
EL- 1	94RM1-00	4307	16.96	163	72.7	4.9	3.5	68.2
EL- 2	94RM2-2	3972	16.24	181	77.2	5.6	4.0	54.3
EL- 3	94RM2-4	4540	17.48	139	77.3	5.4	4.0	58.1
EL- 4	94RM3-1	4385	19.70	170	77.7	3.9	4.5	45.3
EL- 5	94RM3-2	4068	19.83	188	74.4	4.9	3.7	64.8
EL- 6	94RM3-6	4908	19.83	170	78.8	3.9	4.2	46.7
EL- 7	94RM4-2	5140	20.60	176	78.4	4.4	3.8	59.6

TEST 5697. RHIZOMANIA EVALUATION OF FC & E.LANSING LINES, BLOCK 2S, SALINAS, CA., 1997

(cont.)

Variety	Description <sup>1</sup>	Acre Yield		Beets/ 100'	Sucrose %	RJAP %	Powdery Mildew		Rhizomania %R
		Sugar	Beets				Mean	DI	
		Lbs	Tons						
E.Lansing entries (cont.)									
EL- 8	94RM-5-1	4622	20.69	177	11.14	76.0	4.6	3.9	54.5
EL- 9	94Rm-5-2 & -5-3	4056	18.53	163	11.00	74.6	5.8	3.6	63.1
EL-10	94RM10-2	5309	21.17	186	12.54	76.2	4.9	3.3	75.2
EL-11	94RM10-4	5289	22.35	174	11.95	76.3	4.6	3.5	70.7
EL-12	94RM14-1	5129	20.09	179	12.80	79.4	5.8	3.4	76.7
EL-13	94RM14-2	4824	19.30	191	12.60	77.5	6.3	3.1	81.2
EL-14	96RM10-2	4829	19.91	186	12.15	77.1	5.4	3.3	73.2
EL-15	96RM10-5	5123	20.78	192	12.24	77.6	5.5	3.6	66.8
EL-16	96RM11-2	5438	22.80	183	11.95	76.4	5.5	3.4	69.8
EL-17	96RM11-3	3837	18.04	176	10.59	76.8	6.0	3.8	63.0
EL-18	96RM12-0	3753	16.20	189	11.55	77.5	4.6	4.2	49.5
EL-19	96RM13-1	5398	21.54	191	12.54	80.5	5.3	3.6	66.0
EL-20	96RM13-2	5649	23.56	176	12.00	77.1	5.1	3.4	67.7
EL-21	96RM14-1	5482	21.72	181	12.64	77.5	5.6	3.3	77.8
EL-22	96RM14-2	4749	20.46	176	11.59	78.6	5.5	3.2	75.5
EL-23	96RM15-2	4151	19.12	172	10.81	78.0	5.0	3.4	69.8
EL-24	96RM15-3	5109	20.15	192	12.65	78.5	5.1	3.3	73.3
EL-25	96RR (Rhizoc.resist.)	2179	10.41	186	10.49	74.6	5.5	4.4	40.6
Mean		4486.1	18.89	179.4	11.84	76.9	5.1	3.7	62.3
LSD (.05)		942.5	3.45	18.9	1.10	4.1	0.8	0.5	13.2
C.V. (%)		21.3	18.53	10.7	9.41	5.4	15.4	12.7	21.5
F value		6.7**	6.04**	3.3**	5.91**	1.4NS	5.1**	8.4**	7.6**

NOTE: Test hand harvested and scored for rhizomania. DI = disease index and %R = % resistant. Roots rated on a scale of 0 to 9 where 9 = dead. %R = classes 0-3 divided by total. DI is mean individual rating. After rating, 3+ of the most resistant roots were selected and placed in plastic bags. The whole plot was weighed but the selected roots were not included in sugar samples. Powdery mildew rated late in season on a scale of 0 to 9 where 9 = highly susceptible. RJAP = raw juice apparent purity = %S/% soluble solids.

<sup>1</sup>US H11 = susc. check. 6808m = monogerm line, mostly susceptible to rhizomania. 6869 = monogerm population with Rz segregating. 6835H11M = C911-4aa x CTR, mm line composite. EL-1 thru EL-9 have Rz from R276 (= C82). EL-10 thru EL-24 have Rz from R280 (= C80). EL-1 thru EL-24 have smooth root line parentage.



TEST 1797. EVALUATION OF MONOGERM CONVERSIONS FROM MULTIGERM LINES, SALINAS, CA., 1997

24 entries x 8 reps., RCB  
1-row plots, 21 ft. long

Planted: April 10, 1997  
Harvested: October 1, 1997

Variety	Description	Acre Yield		Beets/ 100'	Sucrose %	Root %	RJAP %	Powdery Mildew Score
		Sugar	Beets					
		Lbs	Tons					
6869	5869mmaa x A	8758	33.10	193	13.23	0.0	79.4	7.4
5911-4M	RZM 4911-4Maa x A, (C911-4)	11513	40.40	182	14.25	0.0	79.3	4.6
6911-4-7	RZM 5911-4-7mm	9163	32.90	185	13.96	0.0	80.1	4.6
6869H11	5911-4mmaa x 5869	10959	39.28	157	13.95	0.0	79.6	5.6
6869H15	5915aa x 5869	10652	39.80	183	13.38	0.0	79.4	6.4
6869H25	5925aa x 5869	10690	39.55	173	13.52	0.0	80.3	6.3
6835H11M	RZM 4911-4Maa x 835 (C)	9827	37.44	171	13.13	0.0	80.1	7.1
6835H18	RZM 4918aa x 835 (C)	9745	38.40	173	12.77	0.0	80.3	7.0
6828m	RZM 5828-#s, F2 (911-4H#saa x mm, O-T)	9009	32.50	191	13.84	0.5	79.9	7.0
6836M	RZM 5911-4-#, 5829-#, 5830-#, 5831-#M	9801	33.50	179	14.64	0.0	78.7	5.5
6837m	T-O RZM 5911-4-#, ..., F3 (911-4H#aa x mm, T-O)	9643	34.30	168	14.09	0.0	80.6	6.3
6831-4	RZM, T-O 4831-4mm, F2 (911-4 x mm, O-T)	9231	30.95	158	14.91	0.0	76.9	5.3
Mean		9915.8	36.01	176.2	13.81	0.1	79.6	6.1
LSD (.05)		1028.8	3.34	18.2	0.54	0.3	2.1	0.6
C.V. (%)		10.4	9.32	10.4	3.96	642.2	2.6	9.5
F value		5.5**	8.38**	3.2**	10.63**	2.3*	1.8NS	21.8**

NOTES: Multigerm germplasm lines still have better combinations of disease resistance (VYR, ER, PMR, etc.) than monogerm lines. Monogerm plants occur within some multigerm lines and are being isolated (e.g., 6911-4-7). In addition, MM x mm population crosses have been made from which to select mm, disease resistant types (e.g., 6831-4).

6869 = mm populations from popn-867 x popn-890. 5911-4 & 4911-4 = C911-4 multigerm line that was found to segregate for monogerm. 5915, 5925, & 4918 = MM popns similar to C918.

Moderate rhizomania. High nitrogen status. See Test 3497.

TEST 3497. EVALUATION OF MONOGERM POPULATIONS FOR RESISTANCE TO RHIZOMANIA, BLOCK 2S, SALINAS, CA., 1997

16 entries x 8 replications, RCB  
1-row plots, 20 ft. long

Planted: April 30, 1997  
Harvested: October 23, 1997

Variety	Description	Acre Yield		Sucrose %	Beets/ 100'	Powdery Mildew Score	RJAP %
		Sugar Lbs	Beets Tons				
US H11	113102, 3-18-97	4690	21.10	11.13	161	7.3	78.2
6869H11M	5911-4Maa x 5869	8798	31.71	13.88	153	6.0	81.2
6835H11M	RZM 4911-4Maa x 835(C)	7833	29.21	13.41	161	6.3	80.2
6835H10	5810mmaa x 835(C)	5328	20.90	12.76	157	6.6	80.6
6869(Iso)	RZM 5869mm	6238	23.04	13.55	170	6.1	81.2
6869(Sp)	5869mmaa x A	7141	26.10	13.68	167	6.0	80.8
6828m	RZM 5828-3, -6, -12, -13mm	5520	20.60	13.39	149	6.3	77.1
6833m	RZM 5833-#s(C)mm	6398	23.90	13.39	148	6.9	78.2
6833%M	RZM-#S 4833%M	6174	22.70	13.60	148	6.1	78.3
6834%M	RZM-#S 4834%Mmm	6960	24.34	14.27	157	6.6	80.3
6836M	RZM 5911-4-#, 5829-#, ...M	6005	20.98	14.40	133	5.0	78.8
6837m	T-O RZM 5911-4-#, 5829-#, ...mm	7401	26.63	13.91	147	5.8	78.3
6835H34	RZM 5834mmaa x 835(C)	5769	22.98	12.68	148	6.9	80.4
6835H67	RZM 5867NBmmaa x 835(C)	7196	26.40	13.65	148	6.9	80.1
6835H69	5869mmaa x 835(C)	6515	24.57	13.24	156	6.3	81.8
5911-4M	RZM 4911-4Maa x A (C911-4)	8555	30.66	13.95	138	4.6	80.1
Mean		6657.6	24.7	13.43	152.5	6.2	79.7
LSD (.05)		890.3	3.0	0.90	19.0	8.4	2.6
C.V. (%)		13.5	12.4	6.75	12.6	8.4	3.3
F value		12.8**	10.4**	5.77**	2.1*	13.7**	2.2**

NOTES: See Test 1797. Moderate to severe rhizomania.

6828 = monogerm, Rz selection from C911-4mmaa x mm, O-T lines. 6833 = popn selected from popn-867aa x mm, O-T.  
6834 = popn selected from Rz, mmaa x mm, O-T. 6836 = popn selected from C911-4 x mm, O-T. 6837 = mm selection from popn-836. 835(C) = composite of lines C562, C564, C718, C762-17, & C796-43. 6869 = popn selected from popn-867aa x C890-1.

24 entries x 8 reps., RCB(E)  
 1-row plots, 21 ft. long

Planted: April 10, 1997  
 Harvested: September 25, 1997

Variety	Description	Acre Yield		Beets/ 100'	Sucrose %	Root		Powdery Mildew
		Sugar	Beets			Rot	RJAP	
		Lbs	Tons			%	%	
Sources of resistance (C790,C890,C890-#'s)								
0790	8790-S1(C)aa x A, C790,rzrz	6596	29.45	11.19	194	0.0	83.8	7.0
4890m	RZM 3890mmaa x A, C890, Rz	8167	33.60	12.16	167	0.0	81.4	6.8
6890	RZM 5890, C890-1(Rz)	8592	33.65	12.76	190	0.0	80.9	6.1
6812M	RZM 5812M, C890-2/3 (WB41/42)	7537	31.30	12.02	202	0.0	82.4	6.4
6814M	RZM 5814M, C890-4 (PI07)	6408	29.63	10.79	169	0.0	81.0	6.6
6815M	RZM 5815M, C890-5 (R04)	9654	35.40	13.65	174	0.0	81.1	6.0
6816M	RZM 5277M, C890-6 (R05)	7694	33.15	11.61	195	1.5	85.0	6.6
6817M	RZM 5268M, C890-7 (SES)	8781	34.25	12.81	181	0.0	80.3	6.3
6818M	RZM 5270M, 5272M, C890-8 (R22)	8046	31.80	12.63	175	0.0	81.9	5.9
6819M	RZM 5819M, C890-9 (WB151)	9855	37.40	13.19	190	0.0	81.9	6.8
6820M	RZM 5278M, C890-10 (WB169)	7458	30.50	12.21	172	1.5	82.1	6.1
6821M	RZM 5279M, C890-11 (WB258)	7620	31.75	11.98	168	0.8	82.3	6.8
monogerm populations								
6869	5869mmaa x A	8920	34.10	13.06	203	0.0	84.2	6.9
6869m	RZM 5869mm	8306	31.75	13.07	179	0.0	82.9	6.5
6833M	RZM-8S 4833%M	8940	33.15	13.52	191	0.3	80.0	7.0
6834M	RZM-8S 4834%mm	9513	33.90	14.04	178	0.4	80.9	6.6
6859- 8m	Inc. 2859mA(Sp)- 8	7176	25.25	14.23	176	0.0	82.7	7.6
6891-10m	Inc. 2891mA(Sp)-10	8171	29.30	13.95	192	0.0	81.9	6.6
4867-1	Inc. 2867mA(Sp)- 1	8285	30.73	13.51	176	0.0	80.6	6.8
6808	0790mmaa x 808(C) , 0890-#s	7085	31.10	11.43	193	0.0	83.5	6.4
6869H10M	5810Maa x 5869	8207	32.45	12.68	196	0.3	83.0	6.9
6835H10m	5810mmaa x 835(C)	6839	29.35	11.59	196	0.0	83.6	7.4
6835H67	RZM 5867NBmmaa x 835(C)	9848	36.70	13.43	176	0.3	81.6	7.3
6835H69	5869mmaa x 835(C)	8784	34.70	12.65	183	0.0	82.2	7.0
Mean		8186.7	32.27	12.67	184.0	0.2	82.1	6.7
LSD (.05)		783.2	2.31	0.76	19.8	0.9	3.0	0.5
C.V. (%)		9.7	7.28	6.09	10.9	429.1	3.7	6.9
F value		12.5**	10.52**	11.90**	2.4NS	1.9*	1.4NS	7.0**

Moderate rhizomania. High nitrogen status. See Test 3397.

TEST 3397. MONOGERM, SELF-FERTILE LINES & POPNS WITH RESISTANCE FROM DIFFERENT SOURCES,  
BLOCK 2S, SALINAS, CA., 1997

16 entries x 8 replications, RCB  
1-row plots, 20 ft. long

Planted: April 30, 1997  
Harvested: October 23, 1997

Variety	Description	Acre Yield		Beets/ 100'	Sucrose %	Root %	Powdery		RJAP %
		Sugar	Beets				Rot	Score	
		Lbs	Tons						
Sources of resistance (C790,C890,C890-#'s)									
0790	8790-S <sub>1</sub> (C)aa x A, C790	5458	22.47	12.21	183	0.0	5.9	5.9	82.1
4890m	RZM 3890mmaa x A, C890 (Rz)	6459	26.02	12.41	154	0.0	5.9	5.9	80.4
6890	RZM 5890, C890-1 (Rz)	7273	27.18	13.45	173	0.0	5.9	5.9	82.5
6812M	RZM 5812M, C890-2/3 (WB41/42)	6041	23.42	12.93	181	0.0	6.8	6.8	81.1
6814M	RZM 5814M, C890-4 (PI07)	5911	23.57	12.54	175	0.0	6.4	6.4	80.6
6815M	RZM 5815M, C890-5 (R04)	6772	24.41	13.86	179	0.0	6.3	6.3	80.7
6816M	RZM 5277M, C890-6 (R05)	5922	23.45	12.61	169	0.6	5.8	5.8	82.5
6817M	RZM 5268M, C890-7 (SES)	7113	26.20	13.56	159	0.0	6.4	6.4	78.1
6818M	RZM 5270,72M, C890-8 (R22)	6840	25.52	13.40	169	0.0	6.1	6.1	81.0
6819M	RZM 5819M, C890-9 (WB151)	6320	24.70	12.79	144	0.0	6.4	6.4	81.1
6820M	RZM 5278M, C890-10 (WB169)	6452	25.31	12.73	167	0.0	5.8	5.8	81.6
6821M	RZM 5279M, C890-11 (WB258)	6334	24.41	12.96	172	0.0	5.8	5.8	80.7
monogerm populations									
6808m	0790mmaa x 808 (C)	6314	24.58	12.81	173	0.0	6.3	6.3	81.2
6869H10M	5810Maa x 5869	6050	22.93	13.19	161	1.7	6.4	6.4	80.4
6869	5869mmaa x A	6920	25.57	13.55	163	0.0	6.3	6.3	81.4
US H11	113102, 3-18-97	4610	20.34	11.27	167	0.0	7.1	7.1	79.1
Mean		6299.2	24.4	12.89	168.0	0.1	6.2	6.2	80.9
LSD (.05)		815.3	2.8	0.78	19.2	0.9	0.6	0.6	3.0
C.V. (%)		13.1	11.5	6.07	11.6	637.9	9.3	9.3	3.8
F value		5.2**	2.9**	5.25**	2.2**	1.8*	3.6**	3.6**	1.1NS

NOTES: Moderate to severe rhizomania. See Test 2097.

24 entries x 8 reps., RCB(E)  
1-row plots, 21 ft. long  
Planted: April 10, 1997  
Harvested: September 29, 1997

Variety	Description	Acre Yield		Beets/ 100'	Root Rot	RJAP	Powdery Mildew
		Sugar	Beets				
		Lbs	Tons	No.	%	%	Score
Checks and Rhizomania Commercial Hybrids							
B4454	Betaseed, 4454.6382, 2-20-97	8455	33.55	192	0.0	84.2	6.3
B4776R	Betaseed, 4776.6102, 2-20-97	12204	41.85	201	0.0	81.1	4.9
R680H50	F92-790-15CMS x RZM R580,NB	10604	38.10	179	0.3	82.3	6.4
R581H50	F92-790-15CMS x RZM R481-43,-89	10141	38.75	190	0.0	83.2	6.4
KW6770	KWS 6770.5193, 1-10-97	7461	28.55	181	0.0	85.7	7.0
6931H50	F92-790-15CMS x 931(C)	9980	37.05	183	0.0	82.6	7.0
Rival	HH103, 8-29-95	10297	36.12	181	0.0	80.7	7.1
B4038R	Betaseed, L6KJ0190	11884	37.75	184	0.0	83.5	5.8
R678H50	F92-790-15CMS x R578(sp)	10424	37.40	177	0.3	83.1	6.5
R576-89-18H50	F92-790-15CMS x R476-89-18	10294	38.05	189	0.0	84.6	6.5
Colorado Commercial Hybrids							
B1399	Betaseed, 2-18-97	5641	23.34	168	0.0	82.3	7.0
HM55	Hilleshog, 2-18-97	6682	28.35	184	0.0	85.2	7.3
Monohikari	Seedex,2-18-97	7521	28.70	189	0.3	84.0	7.5
HM1605	Hilleshog, 2-18-97	6643	27.00	167	0.0	85.6	7.1
SX-02	Seedex, 2-18-97	6885	27.05	183	0.3	84.8	7.5
ACH205	Amer.Crystal, 2-18-97	6247	26.55	177	0.0	83.8	7.5
Checks and USDA Experimental Hybrids							
SS-781R	Spreckels, L9501612C, 9-4-96	9775	36.19	173	0.0	82.6	7.1
US H11	L111102 (9-24-96)	5200	25.25	201	0.0	82.1	7.9
6913-70H50	F92-790-15CMS x 5913-70	12342	42.10	193	0.0	83.9	6.4
6913-70H70	5869HO x 5913-70 (C913-70)	11071	40.10	200	0.0	82.4	7.3
5911-4H50	F92-790-15CMS x RZM 4911-4	10952	38.60	187	0.3	81.7	6.4
6921H50	F92-790-15CMS x RZM-%S R21(C)	10286	37.85	192	0.0	81.1	7.0
R680H7	5911-4-7CMS x RZM R580,NB	11772	42.65	155	0.0	82.8	6.0
HM 7072	Hilleshog,	11567	36.65	176	0.0	82.9	6.4
Mean		9347.0	34.48	183.4	0.1	83.2	6.8
LSD (.05)		907.6	2.73	19.2	0.4	2.4	0.5
C.V. (%)		9.9	8.05	10.6	621.9	3.0	8.0
F value		47.2**	36.58**	32.25**	0.8NS	2.6**	12.3**

See Test 1697. Grown under moderate rhizomania.

TEST 2197. EVALUATION OF HYBRIDS, SALINAS, CA., 1997

48 entries x 8 reps., RCB(E); 3 subtests, 16 entries x 8 reps., RCB(E) Planted: April 11, 1997  
1-row plots 21 ft. long Harvested: September 24, 1997

Variety	Description <sup>1</sup>	Acre Yield		Beets/ 100'	Sucrose %	RJAP %	Powdery Mildew
		Sugar	Beets				
		Lbs	Tons				
2197-1: Hybrids with C790-15CMS tester, 16V x 8R, RCB(E)							
B4454	Betaseed, 4454.6382, 2-20-97	8513	34.85	12.25	179	84.4	6.4
KW6770	KWS 6770.5193, 1-10-97	6783	27.20	12.46	168	87.3	6.9
R522H52	F92-790-15H39xRZM R522(C), (C51)	10131	40.45	12.55	181	79.7	6.4
R581H50	F92-790-15CMS x RZM R481-43,-89	10064	39.22	12.81	183	82.0	6.0
R576-89-18H50	F92-790-15CMS x R476-89-18	9442	35.85	13.15	183	84.0	6.1
R678H50	F92-790-15CMS x R578 (Sp) (C78)	10059	37.05	13.55	187	82.7	6.3
R678H50NB	5790-15CMS x R578 (Sp)	10534	38.57	13.68	189	83.0	6.3
R678H50-21	5790-15-21CMS x R578 (Sp)	9753	38.20	12.76	178	83.2	5.8
R678H50-23	5790-15-23CMS x R578 (Sp)	10693	40.10	13.32	187	81.4	6.3
R680H50	F92-790-15CMS x RZM R580 (C80)	10121	38.35	13.20	180	85.1	6.5
6931H50	F92-790-15CMS x 931 (C)	10505	38.30	13.74	187	82.7	5.9
5911-4H50 (Sp)	F92-790-15CMS x RZM 4911-4M	11038	40.60	13.60	181	82.8	5.9
6913-70H50	F92-790-15CMSx5913-70 (C913-70)	11032	41.45	13.30	189	79.5	6.0
Y671H50	F92-790-15CMS x Y71 (C)	10248	38.17	13.41	188	86.1	6.1
6921H50	F92-790-15CMS x RZM-8S R21 (C)	10150	38.25	13.27	192	82.5	6.3
US H11	L111102, 9-24-96	5182	25.80	10.05	183	87.9	7.9
Mean		9640.6	37.03	12.95	183.4	83.4	6.3
LSD (.05)		858.3	2.45	0.69	18.7	3.7	0.6
C.V. (%)		9.0	6.70	5.40	10.3	4.4	9.1
F value		26.5**	25.76**	13.08**	0.7NS	3.2**	6.2**

TEST 2197. EVALUATION OF HYBRIDS, SALINAS, CA., 1997.

48 entries x 8 reps., RCB(E). ANOVA to compare means across sets of entries.

Mean	10295.6	38.31	13.40	184.3	83.2	6.2
LSD (.05)	901.4	2.53	0.70	19.0	3.2	0.6
C.V. (%)	8.9	6.70	5.32	10.5	3.9	9.1
F value	14.8**	13.66**	9.82**	1.2NS	1.9**	9.4**

Grown under moderate rhizomania conditions and high nitrogen status.

(cont.)

Variety	Description <sup>1</sup>	Acre Yield		Beets/ 100'	Sucrose %	Beets/ 100'	RJAP %	Powdery	
		Sugar	Beets					Mildew	Score
		Lbs	Tons						
22197-2: Experimental Hybrids, 16V x 8R, RCB(E)									
B477R Rizor	Betaseed, 4776.6102, 2-20-97	12935	44.45	198	14.55	198	82.0	4.0	
	LF291, SES, 2-13-96	10954	35.85	176	15.27	176	82.3	6.1	
	F92-790-15CMS x RZM 4911-4-10M	12483	40.50	181	15.43	181	81.6	5.6	
	F92-790-15CMS x RZM 4915-7-6	8674	31.33	187	13.81	187	84.3	5.5	
6918-3H50 6918-12H50 6918-21H50 R678H7	F92-790-15CMS x RZM 4918-3	9055	36.45	211	12.41	211	84.9	6.4	
	F92-790-15CMS x RZM 4918-12	10026	37.15	188	13.54	188	83.5	4.9	
	F92-790-15CMS x RZM 4918-21	11339	41.70	193	13.59	193	83.7	5.6	
	5911-4-7CMS x R578 (sp) (C78)	11298	41.70	179	13.57	179	83.4	5.6	
R680H31-4 R678H70 R680H70 6913-70H70	5831-4aa x RZM R580,NB (C80)	11298	40.90	179	13.84	179	83.0	6.3	
	5869HO x R578 (sp) (C78)	10746	38.90	182	13.81	182	83.5	7.0	
	5869HO x RZM R580,NB (C80)	10900	40.75	184	13.40	184	82.8	6.6	
	5869HO x 5913-70 (C913-70)	11906	43.25	191	13.74	191	83.3	6.8	
6931H70 6869H11M 6869H25 R678H59	5869HO x 931 (C)	10830	41.05	179	13.16	179	84.7	6.8	
	5911-4Maa x 5869	10254	39.21	180	13.04	180	84.6	6.1	
	5925aa x 5869	9957	38.30	187	12.95	187	82.0	6.5	
	5859%aa x R578 (sp)	10490	37.60	176	13.94	176	82.7	6.8	
Mean		10821.4	39.32	185.8	13.75	185.8	83.3	6.0	
LSD (.05)		1035.5	2.80	17.8	0.71	17.8	3.1	0.6	
C.V. (%)		9.7	7.20	9.7	5.22	9.7	3.7	10.0	
F value		9.1**	10.31**	2.1NS	9.65**	2.1NS	0.9NS	13.9**	

<sup>1</sup>RZM R481-43, -89 ≈ C82. R476-89-18 = C76-89-18. Y71(C) = composite of R22(C51) backcross O.P. lines. R21(C) = composite of R22(C51) backcross MM,S',A:aa lines. 4911-4-10, 4915-7-6, 4918-3, 4918-12, & 4918-21 = increases of S<sub>1</sub> lines selected for Rz & NB. 5911-4-7 = monogerm selection from C911-4. 5831-4 = S<sub>1</sub> selection from F<sub>1</sub>(C911-4mmaa x mm,T-O). 5911-4M = C911-4. 5859% = C859.

TEST 2197. EVALUATION OF HYBRIDS, SALINAS, CA., 1997

(cont.)

Variety	Description <sup>2</sup>	Acre Yield		Beets/ 100'	RJAP %	Powdery Mildew Score	
		Sugar	Beets				
		Lbs	Tons	Sucrose %	No.		
2197-3: Population Hybrids, 16V x 8R, RCB(E)							
Rival	HH103, 8-29-95	11264	39.00	14.45	186	83.0	6.8
SS-781R	Spreckels, L941000, 9-4-96	9850	37.25	13.19	189	81.9	6.8
R678H87	5890aa x R578(sp) (C78)	10411	38.00	13.71	189	82.5	6.6
R678H10	5810aa x R578(sp)	9700	36.42	13.31	180	84.3	6.1
R678H68	5867HO x R578(sp)	10698	39.85	13.41	186	83.1	6.8
R678H68NB	5867NBHO x R578(sp)	10893	39.30	13.86	176	82.3	7.0
R678H95	5895aa x R578(sp)	9802	35.88	13.66	181	81.7	7.1
R678H5	Z325aa x R578(sp)	11745	41.65	14.10	189	83.2	6.1
R678H11M	5911-4Maa x R578(sp)	10932	39.85	13.75	184	82.9	5.3
R680H88	5890HO x RZM R580,NB (C80)	9846	37.70	13.04	177	84.7	6.1
6931H88	5890HO x 931(C)	10485	38.85	13.50	194	82.9	6.4
6931H21	5921H18aa x 931(C)	10637	40.25	13.21	182	80.8	5.9
6921H25	5925aa x RZM- $\phi$ S R21(C)	10388	38.75	13.41	173	81.9	5.9
Y671H25	5925aa x Y71(C)	10494	38.60	13.57	176	81.9	6.3
6935H11M	RZM 4911-4mmMaa x 835(C)	9860	38.25	12.91	190	83.4	6.5
6835H18	RZM 4918aa x 835(C)	9795	37.60	13.05	177	84.8	6.4
Mean		10424.9	38.58	13.51	183.9	82.8	6.4
LSD (.05)		816.4	2.29	0.73	18.7	2.9	0.5
C.V. (%)		7.9	6.00	5.42	10.3	3.6	8.1
F value		4.2**	3.20**	2.51**	1.1NS	1.2NS	6.8**

<sup>2</sup>5890 = C890-1. Z325  $\approx$  CZ25.



TEST 2297. EVALUATION OF TOPCROSS HYBRIDS, SALINAS, CA., 1997

48 entries x 8 reps., RCB(E); 3 subtests, 16 entries x 8 reps., RCB(E) Planted: April 11, 1997  
1-row plots, 21 ft. long Harvested: September 23, 1997

Variety	Description	Acre Yield		Sucrose %	Beets/ 100'	RJAP %
		Sugar	Beets			
		Lbs	Tons			
Test 2297-1: Topcrosses to C78, 16V x 8R, RCB(E)						
R678H33- 1	5833- 1aa x R578 (Sp) (C78)	11284	37.90	14.90	188	83.4
R678H33- 2	5833- 2aa x R578 (Sp)	9659	36.05	13.38	192	81.6
R678H33- 4	5833- 4aa x R578 (Sp)	10384	38.40	13.56	191	81.6
R678H33- 5	5833- 5aa x R578 (Sp)	12213	39.00	15.68	190	81.4
R678H33- 6	5833- 6aa x R578 (Sp)	10290	36.35	14.21	198	81.6
R678H33- 8	5833- 8aa x R578 (Sp)	9877	33.88	14.59	159	81.6
R678H33-12	5833-12aa x R578 (Sp)	11065	37.85	14.63	198	83.0
R678H33-13	5833-13aa x R578 (Sp)	9312	34.00	13.75	161	80.1
R678H68	5867HO x R578 (Sp)	10474	36.25	14.48	186	82.9
R678H68NB	5867NBHO x R578 (Sp)	11105	38.80	14.34	196	82.7
R678H33-17	5833-17aa x R578 (Sp)	10748	37.95	14.18	199	82.5
R678H39	91-762-17CMS x R578 (Sp)	9385	35.45	13.24	195	81.2
R678H67- 1	2867mA (Sp) - 1aa x R578 (Sp)	9912	35.30	14.06	201	81.5
R678H59- 8	2859mA (Sp) - 8aa x R578 (Sp)	9783	33.65	14.55	182	83.0
R678H91-10	2891mA (Sp) -10aa x R578 (Sp)	10588	35.60	14.90	197	83.0
R678H70	5869HO x R578 (Sp)	10111	36.25	13.98	207	82.9
Mean		10386.8	36.42	14.28	190.0	82.1
LSD (.05)		810.4	2.50	0.59	17.6	2.3
C.V. (%)		7.9	6.94	4.17	9.4	2.8
F value		7.1**	3.83**	8.86**	4.3**	1.3NS

TEST 2297. EVALUATION OF TOPCROSS HYBRIDS, SALINAS, CA., 1997  
48 entries x 8 replications, RCB(E). ANOVA to compare means across sets of entries.

Mean	10608.4	37.29	14.25	188.1	81.7
LSD (.05)	804.0	2.53	0.58	18.0	2.2
C.V. (%)	7.7	6.89	4.16	9.7	2.7
F value	7.1**	5.73	5.47**	5.0**	1.6*

TEST 2297. EVALUATION OF TOPCROSS HYBRIDS, SALINAS, CA., 1997

(cont.)

Variety	Description	Acre Yield		Sugar lbs	Beets Tons	Sucrose %	Beets/ 100'	RJAP %
		Sugar	Beets					
Test 2297-2: Checks & Topcrosses to C80, 16V x 8R, RCB(E)								
B4776R	Betaseed, 4776.6102, 2-20-97	11851	40.00			14.80	201	82.3
Rival	HH103 (1031203), 8-29-95	10991	36.78			14.96	196	83.3
SS-781R	Spreckels (941000), 2-28-95	10142	36.82			13.77	181	81.9
R678H50	F92-790-15CMS x R578(sp)	9366	34.70			13.51	198	82.4
Rebecca	Betaseed 4KJ0158, 3-19-97	12682	42.65			14.94	212	83.1
R680H50	F92-790-15CMS x RZM R580,NB	10882	39.15			13.96	196	81.6
R680H11-3	5911-4-3aa x RZM R580,NB(C80)	9918	36.60			13.57	167	81.4
R680H11-5	5911-4-5aa x RZM R580,NB	11487	42.29			13.61	129	78.8
R680H29- 2	5829- 2aa x RZM R580,NB	10922	37.40			14.60	179	80.9
R680H29- 3	5829- 3aa x RZM R580,NB	11753	40.45			14.55	199	81.5
R680H29- 4	5829- 4aa x RZM R580,NB	9454	33.65			14.07	177	80.3
R680H29- 5	5829- 5aa x RZM R580,NB	10568	37.25			14.21	170	81.2
R680H29- 7	5829- 7aa x RZM R580,NB	10361	36.15			14.35	200	82.7
R680H30- 1	5830- 1aa x RZM R580,NB	11007	37.45			14.74	178	81.8
R680H30- 2	5830- 2aa x RZM R580,NB	11167	39.20			14.24	195	81.8
R680H30- 3	5830- 3aa x RZM R580,NB	10672	37.70			14.19	192	82.3
Mean		10826.4	38.01			14.26	185.6	81.7
LSD (.05)		758.8	2.48			0.50	17.7	2.2
C.V. (%)		7.1	6.58			3.56	9.6	2.7
F value		10.5**	7.86**			7.25**	9.5**	2.0*

NOTES: 5833-#'s are monogerm,Rz,S<sub>1</sub> progenies that segregate A:aa; fertile plants were rogued and ms plants topcrossed. Popn-833 = popn-867 x mm,O-T,CTR lines. Also see Tests B397, 3797, 397 & 1497.

Moderate rhizomania infection occurred.

5911-4-#'s, 5829-#'s & 5830-#'s are monogerm,Rz,S<sub>1</sub> progenies. Popn-829 = C309aa x C911-4.  
Popn-830 = popn-790aa x C911-4.

TEST 2297. EVALUATION OF TOPCROSS HYBRIDS, SALINAS, CA., 1997

(cont.)

Variety	Description	Acre Yield		Sugar Lbs	Beets Tons	Sucrose %	Beets/ 100'	RJAP %
		Beets						
		No.						
Test 2297-3: Topcrosses to C80, 16V x 8R, RCB(E)								
R680H31- 2	5831- 2aa x RZM R580,NB	10236	37.00			13.88	192	80.3
R680H31- 3	5831- 3aa x RZM R580,NB	11740	41.25			14.29	180	80.2
R680H31- 4	5831- 4aa x RZM R580,NB	10836	38.29			14.15	169	81.0
R680H31- 5	5831- 5aa x RZM R580,NB	10619	37.40			14.23	192	81.4
R680H31- 6	5831- 6aa x RZM R580,NB	10239	37.30			13.68	183	79.8
R680H31- 7	5831- 7aa x RZM R580,NB	10640	36.05			14.81	183	81.4
R680H31- 8	5831- 8aa x RZM R580,NB	10545	37.20			14.20	196	81.8
R680H31- 9	5831- 9aa x RZM R580,NB	10116	34.85			14.52	186	82.6
R680H31-10	5831-10aa x RZM R580,NB	10932	39.35			13.90	195	81.4
R680H31-11	5831-11aa x RZM R580,NB	11373	39.80			14.30	192	81.3
R680H32- 1	5832- 1aa x RZM R580,NB	11151	38.05			14.71	180	81.8
R680H32- 2	5832- 2aa x RZM R580,NB	10546	36.75			14.35	181	82.4
R680H32- 3	5832- 3aa x RZM R580,NB	9909	35.85			13.82	190	81.7
R680H32- 5	5832- 5aa x RZM R580,NB	11345	38.95			14.57	201	81.3
R680H32- 7	5832- 7aa x RZM R580,NB	9232	32.60			14.19	192	81.2
R680H70	5869HO x RZM R580,NB	10338	38.10			13.65	211	80.1
Mean		10612.2	37.43			14.20	188.8	81.2
LSD (.05)		823.6	2.61			0.59	16.7	2.1
C.V. (%)		7.8	7.05			4.18	8.9	2.6
F value		4.5**	4.82**			2.79*	2.7*	1.1NS

NOTE: 5831-#'s & 5832-#'s are monogerm, RZ, S<sub>1</sub> progenies. Popn-831 = C911-4aa x mm, O-T, CTR lines.  
Popn-832 = (popn-790aa x C918)aa x mm, O-T, CTR lines.

TEST 1697. PERFORMANCE OF HYBRIDS UNDER CRV (CAPITATUM RED LUTEOVIRUS) INFECTION, SALINAS, CA., 1997

24 entries x 8 reps., RCB(E)  
1-row plots, 21 ft. long

Planted: April 10, 1997  
Harvested: October 2, 1997  
Inoculated CRV: June 10, 1997

Variety	Description	Acre Yield			Beets/		Sucrose		Beets/		Powdery	
		Sugar lbs	Loss %	Beets Tons	100'	No.	%	RJAP	Mildew Score	CRV Mean		

Checks and Rhizomania Commercial Hybrids

B4454	Betaseed, 4454.6382, 2-20-97	6858	19	29.20		208	11.74	81.5	6.1	3.7		
B4776R	Betaseed, 4776.6102, 2-20-97	9686	21	36.25		211	13.37	79.3	4.8	5.4		
R680H50	F92-790-15CMS x RZM R580,NB	9160	14	36.60		187	12.52	78.2	6.5	3.6		
R581H50	F92-790-15CMS x RZM R481-43,-89	9925	2	39.29		177	12.61	81.7	6.0	3.4		
KW6770	KWS 6770.5193, 1-10-97	4827	35	22.65		178	10.63	81.0	7.0	4.4		
6931H50	F92-790-15CMS x 931(C)	8551	14	33.90		197	12.64	79.2	6.0	3.7		
Rival	HH103, 8-29-95	7847	24	29.50		199	13.30	79.1	7.6	4.9		
B4038R	Betaseed, L6KJ0190	9089	24	32.39		190	14.05	80.6	6.5	4.9		
R678H50	F92-790-15CMS x R578(sp)	8500	18	34.05		190	12.47	80.0	6.5	4.2		
R576-89-18H50												
	F92-790-15CMS x R476-89-18	8820	14	34.08		179	12.93	83.0	5.9	3.7		

Colorado Commercial Hybrids

B1399	Betaseed, 2-18-97	4168	26	19.89		178	10.47	76.3	7.4	5.4		
HM55	Hilleshog, 2-18-97	4283	36	22.25		182	9.61	80.4	7.6	4.9		
Monohikari	Seedex, 2-18-97	5004	33	21.15		190	11.81	82.9	7.5	4.1		
HM1605	Hilleshog, 2-18-97	4786	28	22.05		174	10.83	80.9	7.1	4.6		
SX-02	Seedex, 2-18-97	4846	30	21.45		167	11.27	84.7	7.4	4.0		
ACH205	Amer.Crystal, 2-18-97	3956	37	19.85		179	9.97	79.9	7.3	4.8		

Checks and USDA Experimental Hybrids

SS-781R	Spreckels, L950161ZC, 9-4-96	7761	21	32.35		194	11.93	78.9	6.9	4.2		
US H11	L111102 (9-24-96)	4409	15	23.05		199	9.51	78.4	7.8	4.0		
6913-70H50	F92-790-15CMSx5913-70 (C913-70)	11403	8	41.85		198	13.60	80.9	6.1	3.0		
6913-70H70	5869HO x 5913-70 (C913-70)	10091	9	39.45		209	12.79	79.9	7.0	3.0		

TEST 1697. PERFORMANCE OF HYBRIDS UNDER CRV (CAPITATUM RED LUTEOVIRUS) INFECTION, SALINAS, CA., 1997

(cont.)

Variety	Description	Acre Yield			Beets/ 100'	RJAP %	Powdery						
		Sugar Lbs	Loss %	Beets Tons			Sucrose %	No.	Score	Mildew	CRV Mean		
Checks and USDA Experimental Hybrids (cont.)													
5911-4H50	F92-790-15CMS x RZM 4911-4	9982	9	38.45	12.97	189	79.3	5.9	3.6				
6921H50	F92-790-15CMS x RZM-8S R21 (C)	8504	17	34.35	12.33	189	79.6	6.5	3.7				
R680H7	5911-4-7CMS x RZM R580,NB	11255	4	42.15	13.34	155	81.6	5.5	3.6				
HM 7072	Hilleshog,	9191	21	31.00	14.84	202	82.4	6.8	5.3				
Mean		7620.8		30.72	12.15	188.3	80.4	6.6	4.2				
LSD (.05)		845.0		2.66	0.76	18.6	3.1	0.6	0.4				
C.V. (%)		11.3		8.78	6.37	10.1	3.9	8.9	10.5				
F value		65.0**		60.70**	26.55**	4.2**	2.6**	13.3**	20.9**				

<sup>1</sup>Test 1697 is CRV inoculated companion test for Test 1997. Estimated %loss for sugar yield is the difference between these two tests where %loss = [(Noninoc. - CRV inoc.)/Noninoc.]100. Tests 1697 & 1997 were grown under moderate rhizomania. Thus, sugar yield is influenced by variety performance and reaction to both CRV and rhizomania. Also, see Tests 2197, 3997, & 4097.

<sup>2</sup>CRV was visually scored for yellowing on a scale of 0-9 where 9 = 100% yellowed canopy. Inoculated with viruliferous aphids. CRV(CPR) is a luteovirus found in CA, TX, CO, NB, and probably Europe that has some properties similar to BWYV but goes systemically to *Chenopodium capitum* whereas BWYV does not.

TEST 3797. TOPCROSS HYBRIDS UNDER RHIZOMANIA, BLOCK 2S, SALINAS, CA., 1997

32 entries x 8 replications, RCB(E)  
1-row plots, 20 ft. long

Planted: May 02, 1997  
Harvested: November 05, 1997

Variety	Description	Acre Yield		Sucrose %	Beets/ 100'	Root Rot %	Powdery		RJAP %
		Sugar	Beets				Mildew	Score	
		Lbs	Tons						
US H11 SS-781R Rival B4776R	113102, 3-18-97	4327	18.27	11.74	164	0.4	7.0		81.8
	950659C, 3-18-97	7011	25.04	14.13	174	0.0	6.4		83.0
	HH103, 1032406, 3-18-97	7251	24.26	14.90	171	0.0	7.0		81.5
	Betaseed 6102, 2-20-97	9990	33.08	15.15	188	0.0	3.6		82.0
R678H50 R678H67-1 R678H33-1 R678H33-2	F92-790-15CMS x R578	7642	25.55	14.99	174	1.7	5.8		82.8
	2867mA(Sp) -1aa x R578	7890	26.66	14.88	177	2.0	6.0		82.6
	5833-1aa x R578	8584	29.40	14.61	180	1.1	6.4		82.5
	5833-2aa x R578	8094	29.35	13.88	158	0.4	6.6		85.3
R678H33-5 R678H33-6 R678H33-12 R678H33-17	5833-5aa x R578	9804	31.05	15.80	170	0.0	5.1		82.7
	5833-6aa x R578	8351	29.40	14.23	165	0.0	6.4		82.7
	5833-12aa x R578	9429	30.56	15.39	164	0.0	6.0		84.5
	5833-17aa x R578	8533	30.24	14.15	144	0.0	5.9		83.0
R680H70 R680H29-2 R680H29-3 R680H29-5	5869HO x RZM R580, NB	8015	28.35	14.19	173	0.7	6.3		82.0
	5829-2aa x RZM R580, NB	8636	29.09	14.84	164	0.0	5.9		79.0
	5829-3aa x RZM R580, NB	8642	29.03	14.90	146	0.0	5.5		82.2
	5829-5aa x RZM R580, NB	8604	29.62	14.52	143	0.4	5.5		81.7
R680H29-7 R680H30-1 R680H30-3 R680H31-3	5829-7aa x RZM R580, NB	8380	29.24	14.35	170	0.0	6.3		81.0
	5830-1aa x RZM R580, NB	8235	27.97	14.70	147	0.5	5.5		81.9
	5830-3aa x RZM R580, NB	7930	29.19	13.57	156	0.0	6.1		80.5
	5831-3aa x RZM R580, NB	9756	32.67	14.93	153	1.3	5.1		82.2
R680H31-4 R680H31-5 R680H31-6 R680H31-7	5831-4aa x RZM R580, NB	8565	30.61	13.98	141	0.9	5.5		80.8
	5831-5aa x RZM R580, NB	8056	28.98	13.99	145	0.4	5.3		78.2
	5831-6aa x RZM R580, NB	8594	29.75	14.24	162	0.7	5.6		81.9
	5831-7aa x RZM R580, NB	8885	28.17	15.81	146	1.6	5.4		82.2

(cont.)

Variety	Description	Acre Yield		Beets/ 100'	Sucrose %	No.	Root Rot	Powdery		RJAP %
		Sugar Lbs	Beets Tons					Mildew Score		
R680H31-9	5831-9aa x RZM R580,NB	8943	29.30	171	15.27		0.0	5.8	82.5	
R680H31-10	5831-10aa x RZM R580,NB	9597	32.87	169	14.66		0.0	4.6	83.4	
R680H31-11	5831-11aa x RZM R580,NB	8883	29.34	146	15.18		0.0	4.9	83.9	
R680H32-1	5832-1aa x RZM R580,NB	7938	26.67	151	14.95		0.0	5.6	81.6	
R680H32-2	5832-2aa x RZM R580,NB	8167	28.28	148	14.46		0.5	6.0	81.9	
R680H32-3	5832-3aa x RZM R580,NB	7724	26.99	153	14.35		1.2	5.4	81.6	
R680H32-5	5832-5aa x RZM R580,NB	8487	28.37	174	14.90		0.8	5.8	81.3	
R680H32-7	5832-7aa x RZM R580,NB	7475	25.79	146	14.51		0.0	6.4	82.2	
Mean		8325.6	28.53	160.4	14.57		0.5	5.8	82.1	
LSD (.05)		940.8	2.81	16.5	0.83		1.6	0.5	3.3	
C.V. (%)		11.5	10.00	10.4	5.77		363.4	9.5	4.1	
F value		9.2**	7.74**	4.9**	6.20**		1.0NS	12.4**	1.3NS	

NOTE: See Test 2297. Test 3797 under moderate-severe rhizomania.

TEST 3997. RHIZOMANIA EVALUATION OF HYBRIDS, BLOCK 2S, SALINAS, CA., 1997

64 entries x 8 replications, RCB; 4 subtests, 16 entries x 8 reps., RCB  
1-row plots, 20 ft. long

Planted: May 1, 1997  
Harvested: October 20 & 22, 1997

Variety	Description	Acre Yield		Sucrose %	Beets/ 100'	RJAP %	Root Rot %	Powdery Mildew	
		Sugar	Beets					Mean	Mean
		Lbs	Tons						
3997-1: Commercial hybrids, 16 entries x 8 rep., RCB									
Rizor	SES, F291, 2-13-96	9495	31.07	15.30	175	79.4	0.0	7.3	
B4454	Betaseed, 6382, 2-20-97	7255	27.69	13.10	194	82.9	0.9	7.0	
Rebecca	Betaseed, 4KJ0158, 3-19-97	11315	39.95	14.16	168	81.4	0.0	5.3	
SS-NB7R	Spreckels, 950840, 11-13-95	8394	30.69	13.70	169	79.9	0.7	7.4	
Hybrids in Test 4197 - BNYVV titer trial									
US H11 <sup>1</sup>	113102, 3-18-97	4865	21.26	11.01	189	80.7	2.1	7.4	
B4776R <sup>1</sup>	Betaseed, 6102, 2-20-97	11012	37.88	14.54	196	81.1	0.0	4.8	
SS-781R <sup>1</sup>	Spreckels, 9506592C, 3-18-97	7891	29.13	13.57	176	84.0	0.7	7.4	
Rival <sup>1</sup>	HH103, 1032406, 3-18-97	7985	28.30	14.15	179	80.1	1.3	7.6	
KW6770 <sup>1</sup>	KWS, 6770.5193, 1-10-97	6203	23.98	12.95	177	81.1	1.8	7.3	
HM7072 <sup>1</sup>	Hilleshog, 4-8-97	9661	30.62	15.70	164	82.8	0.0	7.1	
B4038R <sup>1</sup>	Betaseed, 6KJ0190, 4-7-97	9787	30.35	16.15	185	82.4	1.0	7.3	
6921H50 <sup>1</sup>	F92-790-15CMS x RZM-8S R21(C)	9355	35.27	13.27	175	79.1	0.0	7.5	
Experimental hybrids									
R678H7	5911-4-7CMS x R578	9327	34.66	13.49	165	80.8	0.0	6.9	
Y671H7	5911-4-7CMS x Y71(C)	8961	33.50	13.36	172	82.1	0.0	7.0	
6869H11M	5911-4Maa x 5869	8035	31.01	12.96	174	83.0	2.3	7.1	
6835H11M	RZM 4911-4Maa x 835(C)	7662	30.95	12.35	162	80.1	0.0	7.3	
Mean		8575.1	31.02	13.74	176.2	81.3	0.7	7.0	
LSD (.05)		997.0	3.11	0.79	16.1	2.8	2.6	0.3	
C.V. (%)		11.7	10.11	5.83	9.2	3.4	390.8	4.5	
F value		21.8**	18.00**	20.42**	3.2**	2.1*	0.8NS	25.7**	
TEST 3997. RHIZOMANIA EVALUATION OF HYBRIDS, BLOCK 2S, SALINAS, CA., 1997.									
64 entries x 8 replications, RCB. ANOVA to compare means across sets.									
Mean		8417.5	30.93	13.56	181.3	81.0	0.7	6.9	
LSD (.05)		974.9	3.21	0.72	15.6	2.6	2.5	0.5	
C.V. (%)		11.8	10.54	5.43	8.8	3.3	346.9	6.8	
F value		11.1**	7.99**	11.82**	3.2**	2.1**	0.7NS	5.0**	

Moderate to severe rhizomania. <sup>1</sup>Entries in Test 4197 (BNYVV titer). Also see 3597.



(cont.)

Variety	Description <sup>2</sup>	Acre Yield		Beets/ 100'	Sucrose %	RJAP %	Root Rot %	Powdery Mildew Mean
		Sugar	Beets					
		Lbs	Tons					
3997-2: Exp. hybrids with C790-15CMS tester, 16 entriex x 8 reps., RCB								
R678H50	F92-790-15CMS x R578 (C78)	9009	32.17	189	14.00	84.1	0.4	6.9
R678H50NB	5790-15CMS x R578	8573	30.40	192	14.09	83.0	0.3	6.9
R678H50-21	5790-15-21CMS x R578	9095	32.78	183	13.85	82.3	0.6	6.5
R678H50-23	5790-15-23CMS x R578	8342	31.40	178	13.31	82.3	0.8	6.9
R680H50	F92-790-15CMS x RZM R580 (C80)	9009	32.89	171	13.70	81.5	0.0	7.3
Y671H50	F92-790-15CMS x Y71 (C)	8390	30.51	181	13.75	80.8	0.4	6.9
6913-70H50	F92-790-15CMS x 5913-70 (C911-4)	9033	32.12	182	14.07	80.6	0.0	7.1
6911-4-10H50	F92-790-15CMS x RZM 4911-4-10M 10915	36.99		188	14.79	80.1	0.0	7.0
6915-7-6H50	F92-790-15CMS x RZM 4915-7-6	7986	28.46	183	14.04	81.7	0.0	6.8
6918-3H50	F92-790-15CMS x RZM 4918-3	7823	28.91	207	13.51	82.4	0.0	6.9
6918-12H50	F92-790-15CMS x RZM 4918-12	8426	29.96	191	14.06	80.2	0.6	6.5
6918-21H50	F92-790-15CMS x RZM 4918-21	8828	32.47	188	13.57	80.4	1.1	6.6
6931H50	F92-790-15CMS x 931 (C)	8994	31.56	177	13.90	81.0	0.0	6.8
6921H50	F92-790-15CMS x RZM-8S R21 (C)	9092	34.11	188	13.32	80.2	1.3	6.8
R522H52	F92-790-15H39xRZM R522 (C) (C51)	9456	37.38	189	12.65	77.1	0.3	6.9
US H11	113102, 3-18-97	4692	22.51	179	10.40	78.2	0.4	7.1
Mean		8604.0	31.54	185.3	13.56	81.0	0.4	6.9
LSD (.05)		938.1	2.96	15.9	0.68	2.8	1.4	0.6
C.V. (%)		11.0	9.47	8.7	5.02	3.4	377.9	8.8
F value		14.1**	10.65**	2.1*	15.97**	3.1**	0.6NS	0.5NS

<sup>2</sup>4911-4-10, 4915-7-6, 4918-3, 4918-12, & 4918-21 = increases of S<sub>1</sub> lines selected for Rz & NB.

TEST 3997. RHIZOMANIA EVALUATION OF HYBRIDS, BLOCK 2S, SALINAS, CA., 1997

(cont.)

Variety	Description <sup>3</sup>	Acre Yield		Sucrose %	Beets/ 100'	RJAP %	Root Rot %	Powdery Mildew Mean
		Sugar	Beets					
		Lbs	Tons					
3997-3: Population hybrids, 16 entries x 8 reps., RCB								
R678H10	5810aa x R578 (C78)	7867	29.12	13.49	187	83.0	1.3	7.0
R678H34	5834aa x R578	8487	30.79	13.79	191	81.7	1.9	7.1
R678H59	5859%aa x R578	7753	27.86	13.94	184	82.7	2.4	7.3
R678H59-8	2859mA (Sp) -8aa x R578	7414	26.47	14.05	184	80.4	0.7	7.5
R678H67-1	2867mA (Sp) -1aa x R578	7729	28.46	13.57	178	80.9	0.4	6.9
R678H68	5867HO x R578	7986	29.31	13.65	186	81.3	2.6	7.1
R678H68NB	5867NBHO x R578	8540	30.73	13.88	182	82.4	0.0	7.1
R678H70	5869HO x R578	8105	30.95	13.11	181	81.5	0.0	7.3
R678H87	5890aa x R578	8562	30.90	13.86	170	80.3	1.1	7.1
R678H88	5890HO x R578	8719	31.96	13.64	180	81.6	2.6	6.8
R678H95	5895aa x R578	8398	30.73	13.66	184	82.3	1.1	7.0
R680H70	5869HO x RZM R580,NB	8446	31.56	13.39	171	81.3	0.0	7.6
R680H88	5890HO x RZM R580,NB	8288	31.07	13.34	194	81.7	0.0	7.3
6931H70	5869HO x 931 (C)	8604	31.95	13.48	175	81.1	1.3	7.1
6931H88	5890HO x 931 (C)	8515	31.51	13.54	197	80.4	0.7	6.9
6913-70H70	5869HO x 5913-70 (C913-70)	8886	33.61	13.21	195	81.3	1.0	7.3
Mean		8268.7	30.44	13.60	183.7	81.5	1.1	7.1
LSD (.05)		954.3	3.24	0.66	14.6	2.5	3.2	0.5
C.V. (%)		11.6	10.73	4.87	8.0	3.1	297.7	6.7
F value		1.5NS	2.38**	1.26NS	2.4**	0.8NS	0.7NS	0.9NS

<sup>3</sup>5859% = C859. 5890 = C890-1.

(cont.)

Variety	Description <sup>4</sup>	Acre Yield		Beets/ 100'	RJAP	Root Rot	Powdery Mildew
		Sugar	Beets				
		Lbs	Tons				
3997-4: Experimental Hybrids, 16 entries x 8 reps., RCB							
6931H21	5921H18aa x 931 (C)	8959	33.00	184	79.7	0.0	6.1
6921H15	5915aa x RZM-8S R21 (C)	8682	32.51	169	79.2	0.0	6.6
6921H25	5925aa x RZM-8S R21 (C)	8718	32.06	189	79.5	1.3	7.1
Y671H15	5915aa x Y71 (C)	7999	29.35	169	79.9	0.0	6.6
Y671H25	5925aa x Y71 (C)	8083	29.68	171	81.4	0.4	6.9
6869H25	5925aa x 5869	7814	29.46	162	79.4	0.5	7.0
6835H18	RZM 4918aa x 835 (C)	7124	28.35	179	80.4	0.7	7.3
R678H5	Z325aa x R578	8748	30.18	172	81.2	0.4	7.1
R678H11M	5911-4Maa x R578	8832	31.64	175	81.9	2.6	6.8
B4776R	Betaseed, 6102, 2-20-97	10638	36.27	203	80.4	1.2	4.9
B4454	Betaseed, 6382, 2-20-97	6299	24.45	191	81.0	1.4	7.0
B680H37	4807HO (C306/2CMS) x RZM R580,NB	7185	29.74	188	78.9	1.3	6.8
Y671H37	4807HO (C306/2CMS) x Y71 (C)	6922	29.46	177	78.1	1.8	7.3
6913-70H37	4807HO (C306/2CMS) x 5913-70 (C913-70)						
		8236	32.17	198	79.8	0.9	6.9
R678H39	91-762-17CMS x R578 (C78)	8028	30.51	181	80.1	0.0	6.6
6913-70H39	91-762-17CMS x 5913-70 (C913-70)	9287	32.95	171	82.2	0.8	6.9
Mean		8222.1	30.74	179.9	80.2	0.8	6.7
LSD (.05)		1010.0	3.49	15.8	2.5	2.4	0.4
C.V. (%)		12.4	11.47	8.9	3.1	293.2	6.4
F value		8.5**	4.35**	8.93**	4.1**	1.6NS	7.1**

<sup>4</sup>5921H18, R21 (C), Y71 (C) are backcross lines with C51 (R22) resistance. Z325 ≈ CZ25.

TEST 3597. WESTERN SUGAR, BETASEED & USDA HYBRID EVALUATION, BLOCK 2S, SALINAS, CA., 1997

32 entries x 8 replications, RCB(E)  
1-row plots, 20 ft. long

Planted: April 30, 1997  
Harvested: October 29, 1997

Variety	Description	Acre Yield		Beets/ 100'	Sucrose %	RJAP %	Powdery		Resistance %R
		Sugar	Beets				Mildew	Resistance	
		Lbs	Tons				Mean	DI	
<u>Western Sugar entries</u>									
RM-1	HM1639 - Hillehog	7473	24.09	174	15.52	81.6	6.5	2.7	83.6
RM-2	AC9613 - Amer.Crystal	6232	21.56	168	14.44	83.6	7.6	4.0	53.1
RM-3	HM1632 - Hillehog	7475	26.01	161	14.35	82.7	6.7	3.5	67.9
RM-4 <sup>1</sup>	B4038R - Betaseed	8441	24.41	173	17.31	83.2	7.1	3.5	64.9
RM-5	Monohikari - Seedex check	5327	17.80	183	14.95	84.0	7.4	4.5	36.6
PM 1819	HM PMR hybrid	4708	16.93	169	14.07	80.9	6.9	4.5	36.3
Rizor	SES, F291, 2-13-96	7890	24.75	161	15.97	77.9	7.9	2.9	79.6
HM7072 <sup>1</sup>	Hillehog, 4-8-97	8026	23.88	159	16.84	81.3	6.9	3.2	76.9
<u>Betaseed entries</u>									
B4454	Betaseed, 4454.6382, 2-20-97	4822	16.98	186	14.06	80.2	6.4	4.9	29.3
4CG6202	Betaseed, 4-17-97	6799	21.47	154	15.88	80.3	8.3	3.0	83.4
4KJ0167	Betaseed, 4-17-97	5393	19.30	184	14.07	78.4	8.8	3.1	82.2
5KJ5017	Betaseed, 4-17-97	8211	25.54	169	16.10	81.1	8.2	2.5	97.8
6CG7257	Betaseed, 4-17-97	7109	22.60	159	15.74	80.8	8.4	2.8	92.7
5CG7474	Betaseed, 4-17-97	7006	23.51	168	14.91	82.6	6.7	3.3	77.8
B4776R <sup>1</sup>	Betaseed, 4776.6102, 2-20-97	9952	30.36	183	16.41	83.5	3.1	2.4	94.9
KW6770 <sup>1</sup>	KWS, 6770.5193, 1-10-97	4228	14.86	174	14.29	82.4	6.9	4.5	38.9
<u>USDA entries and checks</u>									
Rival <sup>1</sup>	HH103, 1032406, 3-18-97	7512	24.15	169	15.57	81.3	8.2	2.8	83.7
SS-781R <sup>1</sup>	950659ZC, 3-18-97	5975	21.48	158	13.97	80.3	7.4	3.1	77.1

(cont.)

Variety	Description	Acre Yield		Beets/ 100'	RJAP %	Powdery		
		Sugar	Beets			Mildew	Resistance	
		Lbs	Tons			Mean	DI	
USDA entries and checks (cont.)								
6921H50 <sup>1</sup>	F92-790-15CMS x RZM-8S R21(C)	8064	28.94	173	80.5	6.9	2.9	81.7
US H11 <sup>1</sup>	113102, 3-18-97	3150	13.53	173	79.4	7.8	4.6	36.0
SS-NB7R	Spreckels, 950840, 11-13-95	6741	23.74	156	79.9	7.5	3.4	73.4
Rebecca	Betaseed, 4KJ0158, 3-19-97	9553	31.04	158	82.0	3.8	2.5	91.7
R678H50	F92-790-15CMS x R578 (C78)	6577	23.10	165	82.1	7.3	3.4	68.6
R680H50	F92-790-15CMS x RZM R580 (C80)	7188	24.69	173	83.6	6.7	3.0	78.3
Y671H50	F92-790-15CMS x Y71 (C)	7358	25.87	170	81.8	7.0	3.0	77.9
6931H50	F92-790-15CMS x 931 (C)	6926	24.63	176	83.2	6.7	3.0	78.4
6913-70H50	F92-790-15CMS x 5913-70 (C913-70)	7599		14.93	177	6.7	3.0	84.2
6913-70H70	5869HO x 5913-70 (C913-70)	7354	25.55	178	81.4	7.4	2.8	86.7
R678H70	5869HO x R578 (C78)	7130	25.14	183	82.2	7.9	3.0	83.8
Y671H7	5911-4-7CMS x Y71 (C)	7316	25.23	172	81.7	6.5	3.2	70.0
Y671H25	5925aa x Y71 (C)	7088	24.62	165	82.7	7.0	3.2	72.0
R678H11M	5911-4Maa x R578 (C78)	7647	26.18	164	82.5	6.3	2.9	85.9
Mean		6946.0	23.36	169.9	81.6	7.0	3.3	72.7
ISD (.05)		680.9	2.24	14.8	2.1	0.5	0.4	10.3
C.V. (%)		10.0	9.75	8.8	2.7	6.7	12.3	14.4
F value		34.2**	24.87**	21.31**	3.7**	47.2**	20.8**	25.4**

NOTES: Harvested by hand and each beet scored for rhizomania where 0 = nondiseased and 9 = dead. DI = mean Rating; % Resistant = classes 0 through 3 divided by total. Rhizomania moderate.

Test appeared to have a serious damping-off problem in seeding stage (*Rhizoctonia solani* ?), so remnant seed was used to plant 6097. Post thinning, stands were mostly good and uniform. PM controlled until late with Bayleton. *Cercospora* leaf spot moderate late. Cyst nematode evident at harvest. *Sclerotium rolfsii* caused a few roots to rot. RJAP = raw juice apparent purity.

R21, Y71(C) resistance is from C51 (R22). 5911-4-7CMS is monogerm from C911-4. 5911-4 = C911-4.

<sup>1</sup>Entries in Test 4197(BNYVV titer). Also see Test 3997 for these entries.

TEST 6097. REPLANT OF WESTERN SUGAR, BETASEED & USDA HYBRID EVALUATION, BLOCK 2S, SALINAS, CA., 1997

24 entries x 8 replications, RCB  
1-row plots, 13 ft. long

Planted: June 5, 1997

Harvested: November 6, 1997

Variety	Description	Acre Yield		Sucrose %	Beets/ 100'	Powdery		RJAP %
		Sugar	Beets			Mildew		
		Lbs	Tons			Score		
<u>Western Sugar entries</u>								
RM-1	HM1639 - Hilleshog	4628	16.63	13.99	199	6.4		79.3
RM-2	AC9613 - Amer.Crystal	3736	14.14	13.28	181	6.4		79.8
RM-3	HM1632 - Hilleshog	4354	15.94	13.85	188	6.5		83.2
RM-4 <sup>1</sup>	B4038R - Betaseed	5222	16.90	15.25	205	6.8		80.2
RM-5	Monohikari - Seedex check	3384	12.50	13.61	186	5.6		82.1
6913-70H50	F92-790-15CMS x 5913-70	6028	22.25	13.70	197	5.1		78.5
Rizor	SES,F291,2-13-96	5118	17.56	14.64	196	7.8		77.1
HM7072 <sup>1</sup>	Hilleshog, 4-8-97	4308	13.98	15.20	171	5.6		81.0
<u>Betaseed entries</u>								
B4454	BTS, 4454.6382, 2-20-97	2775	11.00	12.49	204	5.8		78.4
4CG6202	BTS, 4-17-97	3849	13.05	14.85	166	7.0		80.0
4KJ0167	BTS, 4-17-97	4571	17.56	13.00	216	7.0		79.5
5KJ5017	BTS, 4-17-97	5668	18.84	15.10	184	6.5		83.3
6CG7257	BTS, 4-17-97	4637	15.94	14.56	170	6.8		80.3
5CG7474	BTS, 4-17-97	5722	21.83	13.13	186	5.1		77.0
B4776R <sup>1</sup>	BTS, 4776.6102, 2-20-97	5776	21.91	13.19	211	5.3		78.0
KW6770 <sup>1</sup>	KWS, 6770.5193, 1-10-97	2367	9.71	12.15	201	5.6		75.9

(cont.)

Variety	Description	Acre Yield		Beets/ 100'	Sucrose %	Powdery	
		Sugar	Beets			Mildew	RJAP
		Lbs	Tons			Score	%
USDA entries and checks							
Rival <sup>1</sup>	HH103, 1032406, 3-18-97	4523	17.05	185	13.31	7.3	78.6
SS-781R <sup>1</sup>	950659ZC, 3-18-97	4597	18.59	188	12.41	6.1	77.2
6921H50 <sup>1</sup>	F92-790-15CMS x RZM-8S R21 (C)	5573	21.06	206	13.21	6.5	77.3
US H11 <sup>1</sup>	113102, 3-18-97	2002	9.72	199	10.35	5.9	73.4
SS-NB7R	Spreckels, 950840, 11-13-95	4605	16.71	179	13.68	5.9	82.0
Rebecca	Betaseed, 4KJ0158, 3-19-97	5736	21.40	211	13.40	6.9	81.3
R678H50	F92-790-15CMS x R578	5244	18.59	211	14.06	6.1	83.6
6921H15	5915aa x RZM-8S R21 (C)	5570	21.66	177	12.93	5.8	78.2
Mean		4583.0	16.86	192.4	13.56	6.2	79.4
LSD (.05)		1140.5	4.13	26.8	1.04	0.6	4.9
C.V. (%)		25.2	24.79	14.1	7.76	9.0	6.2
F value		7.3**	6.75**	2.2**	8.93**	12.1**	2.1**

NOTES: See test 3597. Test 6097 was planted as a backup to test 3597 after 3597 appeared to be in trouble with damping-off. Ironically, test 6097 had a more severe damping-off and plant loss problem than 3597. Normally, a test with this variability should be discarded, but for what its worth, here it is. Users beware.

<sup>1</sup>Entries in Test 4197(BNYVV titer). Also see Tests 3597 and 3997.

TEST 3897. CBGA SALINAS CODED RHIZOMANIA TEST, SALINAS, CA., 1997

64 entries x 8 replications, RCB (combined 3891-1 & 3897-2) Planted: May 2, 1997  
 1-row plots, 20 ft. long Harvested: (Rep. 1-4) October 20-21, 1997  
 (Rep. 5-8) October 27-28, 1997

Code No.	Variety	Source	Acre Yield		Sucrose %	Beets/ 100' No.	RJAP %	Powdery Mildew		Resistance	
			Sugar	Beets				Score	DI	%R	
			Lbs	Tons							
SR-48	5CG7540	Betaseed	9483	33.43	14.26	183	80.8	5.8	2.2	97.1	
SR-47	Beta 4776R	Betaseed	9476	31.78	15.00	198	79.2	6.0	2.9	88.9	
SR-53	4KJ0164	Betaseed	9036	32.65	13.91	199	83.7	6.0	2.7	94.6	
SR-35	5KJ0142	Betaseed	8804	29.80	14.83	170	82.7	6.3	2.9	91.3	
SR-25	3BG6224	Betaseed	8415	26.91	15.77	180	79.5	6.0	3.3	86.7	
SR-23	3BG6170	Betaseed	8393	28.69	14.84	171	80.6	5.5	3.2	82.9	
SR-42	4KJ0166	Betaseed	8354	30.74	13.61	194	81.9	6.3	3.0	87.1	
SR-21	Beta 4581	Betaseed	8352	28.66	14.58	188	81.8	6.5	2.8	91.8	
SR-43	5CG7514	Betaseed	8343	26.91	15.63	176	81.3	6.3	3.0	88.3	
SR-41	3BG6156	Betaseed	8203	29.38	14.00	191	80.9	6.0	3.4	77.7	
SR-49	Beta 4488R	Betaseed	8030	25.62	15.79	181	80.6	4.8	3.4	77.2	
SR-62	5CG7484	Betaseed	7872	28.49	13.85	171	81.2	6.3	3.2	81.9	
SR-14	Rizor	Spreckels	7844	26.05	15.11	178	79.4	6.5	3.4	78.1	
SR- 8	HM3042	Hilleshog	7771	27.11	14.36	183	82.2	5.3	3.3	71.3	
SR-11	Rival	Spreckels	7639	25.00	15.46	189	79.6	5.3	3.2	83.2	
SR- 2	5KJ5057	Betaseed	7624	26.26	14.61	184	79.9	5.3	3.2	87.1	
SR-40	Beta 4035R	Betaseed	7487	26.10	14.40	179	81.5	6.3	2.9	87.0	
SR-56	3BG6162	Betaseed	7432	27.44	13.61	196	78.9	5.3	3.5	75.6	
SR-59	HM3026	Hilleshog	7306	26.36	13.88	184	81.8	5.3	3.3	73.4	
SR-19	Beta 4006R	Betaseed	7298	24.47	15.11	134	80.0	6.8	3.2	83.3	
SR-38	HM3058	Hilleshog	7295	24.37	15.09	196	81.5	6.0	3.4	74.2	
SR-27	Beta 4684R	Betaseed	7228	24.92	14.61	170	80.2	6.0	2.8	90.8	
SR-32	HM3027	Hilleshog	7119	25.89	13.76	179	81.6	6.8	3.5	70.6	
SR-10	4CG6529	Betaseed	7048	28.31	12.59	162	80.1	6.3	3.3	80.4	



(cont.)

Code No.	Variety	Source	Acre Yield		Beets/ 100'	RJAP %	Powdery Mildew Score	Resistance	
			Sugar Lbs	Beets Tons				DI	%R
SR-33	4KJ0169	Betaseed	7029	26.08	13.35	80.5	5.8	3.3	77.7
SR-44	SS-IV2R	Spreckels	6964	25.75	13.63	80.0	5.8	3.7	70.8
SR-12	SS-NB5R	Spreckels	6891	25.06	13.84	80.0	5.8	3.6	70.0
SR-54	SS-NB7R	Spreckels	6738	23.48	14.46	81.1	6.3	3.1	87.7
SR-46	H95504	Spreckels	6731	24.61	13.69	80.5	6.0	3.4	78.4
SR- 5	SS-432R	Spreckels	6726	23.86	14.26	79.8	6.0	3.7	68.4
SR-28	SS-781R	Spreckels	6696	25.01	13.51	80.9	6.5	3.1	87.0
SR- 6	2J5324	Betaseed	6647	23.72	14.13	79.7	5.8	4.1	57.4
SR-17	5KJ5061	Betaseed	6643	23.55	14.21	79.8	6.3	3.6	71.8
SR- 7	H93392	Spreckels	6560	23.70	13.98	81.5	6.0	3.5	74.6
SR-18	SS-694R	Spreckels	6545	24.60	13.39	80.7	6.5	3.2	82.5
SR-45	SS-338R	Spreckels	6544	23.97	13.83	79.0	6.0	3.6	66.4
SR- 1	HH-102R	Spreckels	6491	22.74	14.31	80.5	6.3	3.8	65.6
SR-61	HH-112R	Spreckels	6478	24.19	13.42	81.2	6.0	3.4	69.3
SR-29	SS-747R	Spreckels	6448	23.53	13.71	79.5	5.5	3.0	83.8
SR-36	HM3059	Hilleshog	6433	22.50	14.38	79.6	6.8	3.8	63.6
SR-51	SS-376R	Spreckels	6382	23.83	13.51	79.2	6.3	3.1	83.3
SR-63	SS-NB2R2	Spreckels	6376	22.89	14.04	81.2	5.8	3.6	69.3
SR-13	6CG7466	Betaseed	6369	23.85	13.43	79.7	6.3	4.5	43.3
SR- 3	HM3048	Hilleshog	6354	22.33	14.30	79.7	5.8	3.6	68.5
SR- 4	6CG7417	Betaseed	6339	21.61	14.95	79.6	6.5	3.3	84.0
SR-22	H93782	Spreckels	6287	22.39	14.09	80.3	6.8	3.8	64.0
SR-52	SS-372R	Spreckels	6228	22.92	13.60	81.0	6.3	4.2	53.9
SR-31	H944120	Spreckels	6175	23.87	13.08	78.5	5.5	3.5	75.9

TEST 3897. CBGA SALINAS CODED RHIZOMANIA TEST, SALINAS, CA., 1997

(cont.)

Code No.	Variety	Source	Acre Yield		Beets/ 100'	RJAP %	Powdery Mildew		Resistance	
			Sugar	Beets			Score	DI	%R	
			Lbs	Tons						
SR-60	H945187	Spreckels	6047	22.61	13.35	80.1	6.5	3.8	58.8	
SR-58	H95555	Spreckels	5949	21.68	13.74	80.3	6.5	3.9	63.2	
SR- 9	SS-289R	Spreckels	5926	21.46	13.86	79.8	6.0	3.8	61.3	
SR-20	H93778	Spreckels	5877	23.79	12.43	78.5	6.0	4.1	55.8	
SR-39	H93203	Spreckels	5871	21.85	13.47	79.1	6.0	4.2	44.4	
SR-55	HH-97R	Spreckels	5844	21.47	13.69	81.7	5.3	3.9	57.7	
SR-26	Rhizosen CT	Spreckels	5743	21.85	13.19	81.0	5.5	4.4	46.8	
SR-24	H95786	Spreckels	5659	22.78	12.48	79.3	5.5	4.0	57.9	
SR-15	H944140	Spreckels	5539	20.28	13.77	80.5	6.0	4.6	43.8	
SR-37	3BG6188	Betaseed	5422	20.06	13.44	79.6	6.0	5.4	15.2	
SR-34	SS-595R	Spreckels	5367	20.54	13.11	80.1	6.0	4.1	50.5	
SR-50	6CG7464	Betaseed	5101	20.77	12.55	80.2	6.0	4.8	33.9	
SR-16	SS-287R	Spreckels	5056	19.99	12.71	80.5	6.5	4.6	41.3	
SR-30	Rhizoguard	Spreckels	4386	17.21	12.84	80.6	6.8	3.6	64.8	
SR-64	US H11	USDA check	3793	16.90	10.84	77.7	6.0	5.5	17.1	
SR-57	US H11	CBGA check	3742	16.96	10.87	78.4	6.0	5.0	25.2	
Mean			6785.1	24.46	13.88	80.3	6.0	3.6	69.6	
LSD (.05)			825.9	2.74	0.72	2.3	1.0	0.5	14.3	
C.V. (%)			12.4	11.41	5.27	3.0	12.0	10.0	14.7	
F value			16.4**	12.07**	13.57**	4.0**	1.6**	12.1**	12.8**	

NOTES: Rhizomania scored on 4 replications (3897-2). Rated on a scale of 0 to 9 where 0 = no visual symptoms and 9 = dead. Most roots rated on odd numbers, where 1 = highly resistant; 3 = moderately resistant; 5 = moderately susceptible; 7 = susceptible; and 9 = dead. For % Resistant, classes 0-3 = resistant; 4-9 = susceptible. Differentiation between resistant vs. susceptible was not discrete.

(cont.)

Code No.	Variety	Source	Acre Yield		Beets/ 100'	Sucrose %	RJAP %	Powdery Mildew		Resistance
			Sugar	Beets				Score	DI %R	
			Lbs	Tons	No.					

NOTES: (cont.)

Powdery mildew controlled August-September with Bayleton, then mildew developed late. PM scored on scale of 0 to 9 where 0 = resistant. PM probably had little effect on yield. A mild infection of *Cercospora leaf spot* occurred. A low level of Southern root rot (*Sclerotium rolfsii*) occurred; rotted and dead plants were measured as missing feet of row. Cyst nematode was evident at harvest and caused mild root bearding. After emergence, many seedlings were attacked by damping-off (*Rhizoctonia solani*?). Because of overplanting, after thinning, most plots had good and uniform stands. In a few cases, stands were significantly reduced, suggesting differential sensitivity and some surviving roots were fangy.

RJAP = raw juice apparent purity.

Correlation coefficients for variables in 3897-1 machine harvested (reps 1-4) to 3897-2 hand harvested (reps 5-8) were 0.87\*\*, 0.81\*\*, and 0.85\*\* for sugar yield, root yield, and % sucrose, respectively.

Correlation coefficients for variables within 3897 (combined) were: % Resistant to sugar yield, root yield, %S, beets/100 ft., RJAP, and DI were 0.81\*\*, 0.77\*\*, 0.66\*\*, 0.11NS, 0.42\*\*, and -0.98\*\*, respectively. DI to sugar yield, root yield, %S, beets/100 ft., and RJAP were -0.81\*\*, -0.78\*\*, -0.63\*\*, -0.13NS, -0.46\*\*, respectively. Sugar yield to root yield, %S, beets/100 ft., and RJAP 0.95\*\*, 0.73\*\*, 0.11NS and 0.47\*\*, respectively. Root yield to %S, beets/100 ft., and RJAP were 0.50\*\*, 0.14NS, and 0.46\*\*, respectively. %S to beets/100 ft. and RJAP were -0.02NS and 0.33\*\*, respectively. To me (RTL) these data and relationships continue to show that gross sugar yield is an adequate and reliable way to measure resistance to rhizomania under the conditions of the Salinas tests. That scoring partially accounts for the symptoms on the tap root but does not account for the infection on the lateral roots that are so important to plant health and growth.

TEST B197. EVALUATION OF EXPERIMENTAL HYBRIDS, IMPERIAL VALLEY, CA., 1996-97

32 entries x 8 replications, RCB (equalized)  
1-row plots, 27 ft. long

Planted: September 10, 1996  
Harvested: May 16 & 19, 1997

Variety	Description	Acre Yield		Beets/ 100'	Sucrose %	Bolters %	Clean Beets %	NO3-N Mean
		Sugar	Beets					
		Lbs	Tons					
Checks								
4006R	Betaseed, 2-8-96	11159	36.91	156	15.14	0.6	92.3	97
Rival	HH103(103120/3), 8-29-95	11112	37.30	167	14.91	2.3	94.3	156
SS-781R	Spreckels(941000), 2-28-95	10839	40.32	149	13.44	2.2	93.3	123
H50 hybrids								
6918-21H50	F92-790-15CMS x RZM 4918-21	12833	42.45	165	15.11	0.5	93.3	80
6913-70H50	F92-790-15CMS x 5913-70	12014	41.03	156	14.66	3.7	92.4	128
R576-89-18H50	F92-790-15CMS x R476-89-18	11851	39.67	158	14.98	3.5	93.7	114
6918-3H50	F92-790-15CMS x RZM 4918-3	11688	39.56	170	14.76	1.0	88.8	67
6918-12H50	F92-790-15CMS x RZM 4918-12	11661	39.25	159	14.92	4.1	92.5	62
RR680H50	F92-790-15CMS x RZM R580(C80)	11514	39.75	156	14.50	1.5	92.8	168
RR678H50	F92-790-15CMS x R578(C78)	11464	39.44	164	14.52	2.5	93.3	114
RR678H50-23	5790-15-23CMS x R578(C78)	11363	39.50	158	14.36	1.4	94.2	143
RR678H50NB	5790-15CMS x R578(C78)	11112	38.82	153	14.33	4.7	94.4	126
6931H50	F92-790-15CMS x 931(C)	11026	38.61	147	14.30	2.3	93.1	114
RR678H50-21	5790-15-21CMS x R578	10950	38.22	144	14.32	2.7	93.7	136
6911-4-10H50	F92-790-15CMS x RZM4911-4-10	10764	34.59	168	15.55	1.5	89.8	43
Y671H50	F92-790-15CMS x Y71(C)	10708	35.76	154	14.96	2.1	92.5	106
6921H50	F92-790-15CMS x RZM-8S R21(C)	10606	37.30	154	14.25	6.7	91.5	138
RS22H50	F92-790-15CMS x C51	10430	37.65	159	13.87	11.2	92.9	186
6915-7-6H50	F92-790-15CMS x RZM 4915-7-6	8222	29.37	158	14.03	4.1	90.1	138

TEST B197. EVALUATION OF EXPERIMENTAL HYBRIDS, IMPERIAL VALLEY, CA., 1996-97

(cont.)

Variety	Description	Acre Yield		Beets/ 100'	Bolters %	Clean Beets %	NO3-N Mean
		Sugar	Beets				
		Lbs	Tons	No.	%	%	
H37 hybrids							
6913-70H37	4807HO (C306CMS) x 5913-70	12231	45.87	142	0.3	92.9	115
R680H37	4807HO (C306CMS) x RZM R580 (C80)	12107	42.41	158	0.3	93.0	112
R578H37	4807HO (C306CMS) x RZM R478	11896	41.44	156	0.9	92.9	82
Y671H37	4807HO (C306CMS) x Y71 (C)	11347	43.47	155	0.3	93.5	137
Popn hybrids							
R678H7	5911-4-7CMS x R578 (C78)	12272	42.02	141	3.8	94.1	102
R678H87	5890aa x R578 (C78)	11276	40.00	156	1.5	93.7	104
6913-70H70	5869HO x 5913-70 (C913-70)	11222	40.33	154	5.6	93.3	143
R680H7	5911-4-7CMS x RZM R580 (C80)	11158	41.50	152	6.8	93.7	126
R680H70	5869HO x RZM R580 (C80)	10939	38.50	138	3.1	94.5	134
6931H70	5869HO x 931 (C)	10700	37.52	137	3.7	93.5	104
R678H68	5867HO x R578 (C78)	10528	38.41	153	2.1	94.3	196
R678H10	5810aa x R578 (C78)	10360	34.47	145	1.8	93.4	83
R678H70	5869HO x R578 (C78)	10219	37.44	159	7.6	92.5	187
Mean		11174.1	39.03	154.4	3.0	92.9	120.6
LSD (.05)		1113.2	3.32	11.1	2.5	1.9	62.0
C.V. (%)		10.1	8.65	7.3	85.5	2.1	52.1
F value		4.2**	6.43**	4.3**	7.3**	3.8**	2.6*

NOTES: No apparent infection with rhizomania. Powdery mildew controlled with sulfur but moderate at harvest. No other diseases noted. Test grown adjacent to Test B297, the A5 Coded Non-rhizomania test.

F92-790-15CMS = C790-68CMS x C790-15. 4807HO = C306CMS. 5911-4-7CMS = CMS of mm plant selected from line C911-4. 5890 = C890-1. R476-89-18 = C76-89-18. R578 = C78. R580 = C80. 5913-70 = C913-70. 4911-4-10, 4915-7-6, 4918-3, 4918-12, & 4918-21 = increases of S<sub>1</sub>'s selected on basis of Rz, nonbolting, and % sucrose.

TEST B397. EVALUATION OF TOPCROSS HYBRIDS, IMPERIAL VALLEY, CA., 1996-97

48 entries x 8 replications, RCB (equalized)  
1-row plots, 18 ft. long

Planted: September 11, 1996  
Harvested: May 13 & 14, 1997

Variety	Description	Acre Yield		Sucrose %	Beets/ 100'	Bolters %	Clean Beets %	NO3-N Mean
		Sugar	Beets					
		Lbs	Tons					
Checks								
4006R	Betaseed, 2/8/96	10870	35.57	15.22	173	0.0	92.4	87
RR680H37	4807HO x RZM R580, NB	10802	40.22	13.43	159	0.0	94.1	176
RR680H50	F92-790-15CMS x RZM R580	10313	37.04	13.96	154	2.0	94.3	188
RR678H70	5869HO x R578 (C78)	10198	36.03	14.19	170	3.4	94.0	137
RR678H50	F92-790-15CMS x R578 (C80)	9945	35.50	14.06	152	0.9	93.6	137
RR680H70	5869HO x RZM R580 (C80)	9897	37.53	13.22	167	2.6	94.7	151
Rival	HH103 (1031203), 8/29/95	9599	32.17	14.92	162	2.6	94.8	176
SSS-781R	Spreckels (941000), 2/28/95	9257	35.45	13.02	161	0.4	94.2	178
Topcrosses to C78								
RR678H33- 5	5833- 5aa x R578 (Sp)	10658	37.27	14.30	154	0.0	93.9	107
RR678H33- 6	5833- 6aa x R578 (Sp)	9984	36.11	13.86	163	2.0	94.0	141
RR678H33- 4	5833- 4aa x R578 (Sp)	9891	39.33	12.58	167	1.2	95.3	227
RR678H33-12	5833-12aa x R578 (Sp)	9850	34.86	14.18	167	0.4	95.0	136
RR678H33- 1	5833- 1aa x R578 (Sp)	9619	34.19	14.05	150	0.9	94.2	156
RR678H33-17	5833-17aa x R578 (Sp)	9598	34.25	13.98	164	0.0	94.6	135
RR678H33- 8	5833- 8aa x R578 (Sp)	9567	34.09	14.06	155	0.0	93.1	147
RR678H33-14	5833-14aa x R578 (Sp)	9181	35.60	12.87	145	1.0	93.1	229
RR678H33-15	5833-15aa x R578 (Sp)	9114	33.95	13.37	144	3.3	94.2	198
RR678H33-19	5833-19aa x R578 (Sp)	9089	31.99	14.22	158	0.0	94.3	149
RR678H33-13	5833-13aa x R578 (Sp)	8774	31.60	13.90	147	0.5	95.5	122
RR678H33- 2	5833- 2aa x R578 (Sp)	8748	33.89	12.88	163	1.8	92.7	151

(cont.)

Variety	Description	Acre Yield		Beets/ 100'	Bolters %	Clean Beets %	NO3-N Mean
		Sugar	Beets				
		Lbs	Tons	No.	%	%	
Topcrosses to C78 (cont.)							
R678H91-10	2891mA (Sp) -10aa x R578 (Sp)	10174	34.28	160	3.1	93.6	86
R678H59- 8	2859mA (Sp) - 8aa x R578 (Sp)	9782	33.11	165	0.9	92.6	90
R678H67- 1	2867mA (Sp) - 1aa x R578 (Sp)	9090	34.65	161	0.5	93.0	136
Topcrosses to C80							
R680H11- 5	5911-4-5aa x RZM R580, NB	10357	40.23	117	12.0	94.5	157
R680H11- 3	5911-4-3aa x RZM R580, NB	9891	34.84	158	0.9	92.2	111
R680H11- 5	5911-4-5aa x RZM R580, NB	10357	40.23	117	12.0	94.5	157
R680H11- 3	5911-4-3aa x RZM R580, NB	9891	34.84	158	0.9	92.2	111
R680H29- 7	5829- 7aa x RZM R580, NB	10750	37.44	165	0.0	94.0	105
R680H29- 3	5829- 3aa x RZM R580, NB	10242	34.30	158	0.9	93.4	95
R680H29- 5	5829- 5aa x RZM R580, NB	9620	34.60	147	1.4	94.1	116
R680H29- 4	5829- 4aa x RZM R580, NB	9414	31.90	165	0.0	92.7	66
R680H29- 2	5829- 2aa x RZM R580, NB	9354	32.74	164	8.7	93.2	104
R680H30- 2	5830- 2aa x RZM R580, NB	10579	37.48	149	0.0	94.0	121
R680H30- 3	5830- 3aa x RZM R580, NB	10304	35.26	151	0.0	93.7	111
R680H30- 1	5830- 1aa x RZM R580, NB	9176	31.10	150	0.0	93.7	76
R680H31- 5	5831- 5aa x RZM R580, NB	10863	37.21	154	1.0	94.2	83
R680H31- 3	5831- 3aa x RZM R580, NB	10712	38.62	154	1.4	94.8	107
R680H31- 6	5831- 6aa x RZM R580, NB	10440	37.46	162	2.0	94.2	97
R680H31- 9	5831- 9aa x RZM R580, NB	10204	36.20	163	2.1	92.0	104
R680H31- 4	5831- 4aa x RZM R580, NB	9954	34.92	149	1.3	94.2	113
R680H31-11	5831-11aa x RZM R580, NB	9609	34.87	147	0.4	94.3	156
R680H31- 8	5831- 8aa x RZM R580, NB	9588	34.90	158	0.9	92.6	128
R680H31-10	5831-10aa x RZM R580, NB	9453	33.99	162	1.2	94.5	116

TEST B397. EVALUATION OF TOPCROSS HYBRIDS, IMPERIAL VALLEY, CA., 1996-97

(cont.)

Variety	Description	Acre Yield		Beets/ 100'	Bolters %	Clean Beets %	NO3-N Mean
		Sugar	Beets				
		Lbs	Tons				
Topcrosses to C80 (cont.)							
R680H31- 7	5831- 7aa x RZM R580,NB	9110	32.16	157	0.0	94.4	115
R680H31- 2	5831- 2aa x RZM R580,NB	8739	31.95	148	2.3	95.3	109
R680H32- 2	5832- 2aa x RZM R580,NB	10807	38.01	163	0.5	94.2	128
R680H32- 3	5832- 3aa x RZM R580,NB	9889	33.81	163	3.1	93.9	73
R680H32- 1	5832- 1aa x RZM R580,NB	9576	33.52	152	0.9	94.5	118
R680H32- 7	5832- 7aa x RZM R580,NB	9376	33.78	158	0.0	93.9	113
R680H32- 5	5832- 5aa x RZM R580,NB	9243	33.33	160	1.3	93.7	101
Mean		9817.7	35.07	157.0	1.5	93.9	128.3
LSD (.05)		1049.4	3.44	14.5	7.9	1.7	55.5
C.V. (%)		10.9	9.95	9.4	163.8	1.9	43.9
F value		2.5**	3.26**	3.1**	6.5**	1.8**	3.4**

NOTES: No apparent infection with rhizomania.

5833-# = S<sub>1</sub> lines from popn-833 = 3867aa x composite mm, O-types. 5911-4-# = S<sub>1</sub>'s from C911-4m. 5829-# = S<sub>1</sub>'s from 4911-4H25 = C309aa x C911-4m. 5830-# = S<sub>1</sub>'s from 4911-4H90 = C890aa x C911-4m. 5831-# = S<sub>1</sub>'s from from C911-4mnaa x composite mm, O-types. 5832-# = S<sub>1</sub>'s from 2915H90aa x composite mm, O-type.



TEST B497. EVALUATION OF POPULATION HYBRIDS, IMPERIAL VALLEY, CA., 1996-97

24 entries x 8 replications, RCB (equalized)  
1-row plots, 18 ft. long

Planted: September 11, 1996  
Harvested: May 13, 1997

Variety	Description	Acre Yield		Beets/ 100'	Bolters %	Clean Beets %	NO3-N Mean
		Sugar	Beets				
		Lbs	Tons				
Checks							
4006R	4807HO(C306CMS)xRZM R478NB	10729	40.63	157	0.0	93.3	119
Rival	Betaseed,2-8-96	10296	33.63	170	0.8	91.3	42
SS781R	HH103(1031203),8-29-95	10070	34.50	172	1.6	93.4	129
	Spreckels(941000),2-28-95	9556	36.14	147	0.0	93.8	111
Popn Hybrids							
6931H50	F92-790-15CMS x 931(C)	10050	35.65	161	2.7	92.1	110
RR680H88	5890HO x RZM R580,NB(C80)	9978	36.10	167	0.0	93.3	86
RR678H50	F92-790-15CMS x R578(sp) (C78)	9838	35.43	163	3.1	92.9	91
6931H70	5869HO x 931(C)	9824	35.48	156	2.1	91.4	91
RR678H70	5869HO x R578(sp)	9792	36.34	156	5.5	94.6	102
6869H25	5925aa x 5869	9649	34.62	153	0.5	93.4	112
RR678H68NB	5867NBHO x R578(sp)	9636	36.21	156	10.9	94.4	123
RR678H87	5890aa x R578(sp)	9449	34.54	167	0.4	91.8	90
6931H88	5890HO x 931(C)	9400	34.13	158	1.1	91.7	89
6835H18	RZM 4918aa x 835(C)	9388	36.01	143	0.0	92.6	105
R678H10	5810aa x R578(sp)	9239	33.48	163	0.4	93.6	98
6921H50	F92-790-15CMSxRZM-%S R21(C)	9212	33.80	161	5.0	92.8	126
6931H21	5921H18aa x 931(C)	9194	34.19	161	2.8	91.4	105
6869H11M	5911-4Maa x 5869	9166	31.85	145	0.0	93.5	59
RR678H68	5867HO x R578(sp)	9052	36.05	163	2.1	93.9	189
6921H25	5925aa x RZM-%S R21(C)	8946	32.95	152	2.8	93.4	99

TEST B497. EVALUATION OF POPULATION HYBRIDS, IMPERIAL VALLEY, CA., 1996-97

(cont.)

Variety	Description	Acre Yield		Beets/ 100'	Bolters %	Clean Beets %	NO3-N Mean
		Sugar	Beets				
		Lbs	Tons				
<u>Popn Hybrids (cont.)</u>							
R678H95	5895aa x R578 (Sp)	8938	35.13	161	0.4	94.9	146
R678H11M	5911-4Maa x R578 (Sp)	8709	33.37	154	3.6	93.2	109
6835H11M	RZM 4911-4mmMaa x 835 (C)	8694	33.98	158	1.3	92.5	105
Y671H25	5925aa x Y71 (C)	8594	32.51	149	3.5	92.8	84
Mean		9474.9	34.86	158.0	2.1	93.0	105.1
LSD (.05)		870.5	2.62	12.1	2.8	1.7	44.0
C.V. (%)		9.3	7.64	7.8	134.4	1.8	42.5
F value		3.0**	3.52**	3.0NS	6.1**	2.9**	3.2**

NOTES: No apparent infection with rhizomania.

TEST B297. AREA 5 CODED NON-RHIZOMANIA YIELD TEST, IMPERIAL VALLEY, CA., 1996-97

32 entries x 8 replications, RCB (equalized)  
 1-row plots, 27 ft. long

Planted: September 10, 1996  
 Harvested: May 15, 1997

Code	Variety	Source	Acre Yield		Sucrose %	Beets/ 100' No.	Bolters %	Clean Beets %	NO3-N Mean
			Sugar Lbs	Beets Tons					
14	Rizor	Spreckels	11510	41.53	13.88	177	6.1	92.6	142
7	5CG7540	Betaseed	11136	42.62	13.09	149	0.3	92.0	204
10	BETA 4776R	Betaseed	11067	41.05	13.47	178	0.2	94.1	143
3	BETA 4035R	Betaseed	10994	41.52	13.23	159	0.5	93.0	176
21	BETA 4006R	Betaseed	10947	39.19	13.95	177	1.0	91.6	87
19	6CG7466	Betaseed	10870	39.51	13.75	153	1.9	94.2	125
9	4KJ0164	Betaseed	10808	43.84	12.30	171	0.0	92.3	266
5	4KJ0169	Betaseed	10805	39.73	13.61	185	0.2	91.4	168
20	HM 3058	Hilleshog	10768	38.52	13.99	174	0.8	94.0	142
30	R680H37	USDA	10613	43.63	12.16	144	0.0	93.4	177
22	Rival	Spreckels	10564	38.16	13.85	172	5.7	93.9	119
11	BETA 4684R	Betaseed	10464	39.06	13.39	163	0.3	95.3	176
29	R680H50	USDA	10441	40.95	12.74	158	2.7	94.1	197
26	R678H50	USDA	10409	39.82	13.09	162	5.5	93.7	135
24	H95786	Spreckels	10367	43.74	11.87	179	0.5	93.1	188
32	6913-70H37	USDA	10353	44.61	11.59	145	2.6	92.9	189
25	SS-NB7R	Spreckels	10200	39.55	12.88	154	1.8	94.1	163
17	6CG7464	Betaseed	10152	38.67	13.11	154	0.0	94.0	127
4	BETA 4581	Betaseed	10074	40.12	12.55	175	9.8	94.8	206
12	H93778	Spreckels	9997	40.06	12.49	183	1.0	92.3	182
28	R678H70	USDA	9891	38.61	12.77	167	8.4	93.7	155
31	6931H50	USDA	9858	36.64	13.48	163	5.3	92.2	123
27	R678H88	USDA	9815	39.48	12.43	160	2.9	94.1	160
23	SS-IV2R	Spreckels	9609	39.01	12.31	169	2.2	93.8	199

TEST B297. AREA 5 CODED NON-RHIZOMANIA YIELD TEST, IMPERIAL VALLEY, CA., 1996-97

(cont.)

Code	Variety	Source	Acre Yield		Beets/ 100'	Bolters %	Clean Beets %	NO3-N Mean
			Sugar Lbs	Beets Tons				
15	SS-781R	Spreckels	9503	39.05	162	0.6	95.0	168
8	6CG7417	Betaseed	9454	34.32	175	2.3	92.2	74
13	HH-97R	Spreckels	9242	36.56	167	0.6	94.5	162
2	HM 3048	Hilleshog	9224	33.91	176	3.6	93.6	150
16	SS-694R	Spreckels	8566	35.50	164	2.6	93.4	166
18	Rhizoguard	Spreckels	8143	31.47	176	0.3	94.5	142
6	HM 3059	Hilleshog	8135	31.48	162	41.6	91.3	143
1	US H11	Check	7984	33.83	156	0.6	91.9	206
Mean			10061.3	38.93	165.9	3.5	93.3	161.1
LSD (.05)			967.5	3.27	11.7	3.5	1.9	48.5
C.V. (%)			9.8	8.54	7.2	100.7	2.0	30.6
F value			6.9**	8.18**	6.7**	35.3**	2.7**	4.7**

TEST B297. AREA 5 CODED NON-RHIZOMANIA YIELD TEST, IMPERIAL VALLEY, CA., 1996-97

(cont.)

Code	Variety	Recover.		Recover.		Sugar	SugarLoss	Sodium		Potassium		NH <sub>2</sub> -N	Impur.
		lbs/a	lbs/t	%	lbs/a			ppm	ppm	ppm	ppm		Value
14	Rizor	9662	233	83.9	1848			503		2514		710	14793
7	5CG7540	8933	210	80.2	2203			861		2867		742	17230
10	BETA 4776R	9166	223	82.8	1901			548		2474		770	15418
3	BETA 4035R	9094	219	82.6	1901			481		2857		679	15282
21	BETA 4006R	9506	242	86.7	1441			535		2046		563	12338
19	6CG7466	9207	233	84.6	1663			491		2497		633	13973
9	4KJ0164	8599	195	79.3	2209			787		2828		743	16881
5	4KJ0169	9098	230	84.3	1707			458		2414		689	14183
20	HM 3058	8955	233	83.1	1814			543		2823		711	15714
30	R680H37	8353	191	78.6	2260			739		3187		713	17327
22	Rival	8810	231	83.3	1754			533		2678		716	15364
11	BETA 4684R	8524	218	81.5	1940			582		2784		789	16495
29	R680H50	8463	206	80.9	1979			644		2990		680	16185
26	R678H50	8533	215	82.0	1876			562		2895		677	15633
24	H95786	8426	193	81.0	1941			751		2843		534	14806
32	6913-70H37	7904	177	76.1	2449			752		3252		799	18357
25	SS-NB7R	8308	210	81.4	1892			582		2799		720	15874
17	6CG7464	8390	217	82.5	1762			555		2735		672	15157
4	BETA 4581	7875	196	78.1	2199			611		3001		904	18224
12	H93778	7937	198	79.3	2060			709		3136		717	17136
28	R678H70	8096	209	81.7	1795			574		2817		681	15518
31	6931H50	8205	225	83.3	1653			471		2818		658	14940
27	R678H88	7888	200	80.4	1927			562		3058		697	16232
23	SS-IV2R	7596	195	79.1	2013			614		2831		833	17144

TEST B297. AREA 5 CODED NON-RHIZOMANIA YIELD TEST, IMPERIAL VALLEY, CA., 1996-97

(cont.)

Code	Variety	Recover.		Recover.		Known Sugar Loss	Sodium		Potassium		NH <sub>2</sub> -N	Impur. Value
		Sugar lbs/a	Sugar lbs/t	%	lbs/a		ppm	ppm	ppm	ppm		
15	SS-781R	7720	198	81.2	1783		645		2727		648	15229
8	6CG7417	7942	230	83.8	1512		384		2504		748	14705
13	HH-97R	7610	207	82.2	1632		674		2591		636	14877
2	HM 3048	7621	224	82.6	1603		591		2654		739	15725
16	SS-694R	6879	194	80.3	1687		672		2795		688	15872
18	Rhizoguard	6756	214	82.9	1387		687		2650		589	14631
6	HM 3059	6812	217	83.7	1323		662		2533		552	13897
1	US H11	6380	188	79.8	1604		574		2937		681	15824
Mean		8226.5	211.6	81.7	1834.9		604.3		2766.7		697.2	15655.1
LSD (.05)		869.4	13.9	2.3	257.7		122.8		266.0		103.4	1667.2
C.V. (%)		10.7	6.7	2.8	14.3		20.6		9.8		15.1	10.6
F value		6.7**	10.6**	7.2**	7.9**		5.8**		6.7**		4.4**	4.8**

NOTES: No evidence of rhizomania. Nitrogen status high. Off water about 2 weeks when harvested. No significant disease or insect problems observed.

USDA entries: R678H50 = C790-15CMS x C78; R678H88 = C890-1CMS x C78; R678H70 = 5869HO x C78; R680H50 = C790-15CMS x C80; R680H37 = C306CMS x C80; 6931H50 = C790-15CMS x 931(C); and 6913-70H37 = C306CMS x C913-70.

32 entries x 8 replications, RCB (equalized)  
1-row plots, 27 ft. long

Planted: September 12, 1996  
Harvested: May 21 & 22, 1997

Variety	Description	Acre Yield		Beets/ 100'	Bolters %	Clean Beets %	NO3-N Mean
		Sugar	Beets				
		Lbs	Tons				
<u>Checks</u>							
Rival	HH103(103R03), 8/29/95	10643	32.03	155	0.0	94.0	92
4006R	Betaseed, 2/8/96	10315	32.46	169	0.0	92.7	81
SS-781R	Spreckels(941000), 2/28/95	9291	33.31	144	0.0	94.4	128
<u>H50 Hybrids</u>							
6918-12H50	F92-790-15CMS x RZM 4918-12	11457	34.93	167	0.3	92.5	55
6913-70H50	F92-790-15CMS x 5913-70	10751	33.43	160	0.3	93.1	60
6931H50	F92-790-15CMS x 913 (C)	10745	33.16	149	0.0	93.0	66
6921H50	F92-790-15CMS x RZM-%SR21 (C)	10588	32.82	152	1.2	93.9	112
R680H50	F92-790-15CMS x RZM R580, NB	10548	34.83	147	0.3	92.8	145
6918-21H50	F92-790-15CMS x RZM 4918-21	10426	31.55	157	0.0	93.2	47
6918-3H50	F92-790-15CMS x RZM 4918-3	10201	31.64	155	0.0	89.9	41
6911-4-10H50	F92-790-15CMS x RZM 4911-4-10M	10049	30.21	158	0.0	90.0	42
R581H50	F92-790-15CMSxRZM R481-43, -89	9969	32.94	156	1.7	93.8	116
Y671H50	F92-790-15CMS x Y71 (C)	9959	31.72	149	0.9	92.8	84
R678H50	F92-790-15CMS x R578 (Sp)	9706	33.30	156	0.3	93.1	106
R522H50	F92-790-15CMS x C51	8806	30.29	150	6.6	92.4	113
6915-7-6H50	F92-790-15CMS x RZM 4915-7-6	7991	26.67	159	0.3	89.7	84
<u>H37 Hybrids</u>							
R578H37	4807HO (C306CMS) x RZMR478NB	10727	36.19	153	0.0	93.0	88
6913-70H37	4807HO (C306CMS) x 5913-70	10095	35.79	148	0.0	92.7	118
Y671H37	4807HO (C306CMS) x Y71 (C)	9673	33.44	146	0.0	93.8	84
R680H37	4807HO (C306CMS) x RZM580, NB	9090	33.37	152	0.0	93.3	156

TEST B597. EVALUATION OF EXPERIMENTAL HYBRIDS UNDER RHIZOMANIA, IMPERIAL VALLEY, CA., 1996-97

(cont.)

Variety	Description	Acre Yield		Beets/ 100'	Bolters %	Clean Beets %	NO3-N Mean
		Sugar	Beets				
		Lbs	Tons				
<u>H7 Hybrids</u>							
R680H7	5911-4-7CMS x RZM R580,NB	10585	34.77	139	0.0	94.0	80
R678H7	5911-4-7CMS x R578 (Sp)	10177	33.22	148	0.0	94.7	110
Y671H7	5911-4-7CMS x Y71 (C)	10103	32.46	144	0.7	93.2	73
<u>Popn Hybrids</u>							
R678H68	5867HO x R578 (Sp)	10611	36.89	158	0.6	94.5	97
R680H88	5890HO x RZM R580,NB	10412	33.21	150	0.0	94.1	90
R678H88	5890HO x R578 (Sp)	10131	31.80	146	0.0	93.3	85
6931H80	5869HO x 913 (C)	10118	31.73	144	1.3	93.6	55
6913-70H70	5869HO x 5913-70	9927	32.18	150	3.0	92.2	87
R678H70	5869HO x R578 (Sp)	9787	31.41	165	0.3	91.8	114
6931H88	5890HO x 913 (C)	9741	31.54	151	0.0	92.8	88
R680H70	5869HO x RZM R580,NB	9541	31.45	149	1.4	94.5	105
6869H11M	5911-4Maa x 5869	9357	30.32	148	0.0	92.7	93
Mean		10047.5	32.66	152.3	0.6	93.0	90.5
LSD (.05)		1121.7	3.18	13.1	1.4	2.3	46.0
C.V. (%)		11.3	9.88	8.7	233.0	2.5	51.5
F value		2.7**	3.00**	2.2NS	6.7**	2.2**	2.8

NOTES: Test under variable but mild rhizomania infection. See Tests B197, et al. for descriptions.



TEST B797. EVALUATION OF LINES AND POPULATION HYBRIDS UNDER MILD RHIZOMANIA,  
IMPERIAL VALLEY, CA., 1996-97

16 entries x 8 replications, RCB (equalized)  
1-row plots, 27 ft. long

Planted: September 13, 1996  
Harvested: May 20, 1997

Variety	Description	Acre Yield		Beets/ 100'	Bolters %	Clean Beets %	NO3-N Mean
		Sugar Lbs	Beets Tons				
<b>Checks</b>							
Rival	HH103 (1031203), 8/29/95	10929	32.66	163	0.3	93.2	67
SS-781R	Spreckels (941000), 2/28/95	10340	33.79	150	0.0	93.4	30
US H11	L113401, 11/16/94	6452	23.98	157	0.0	90.2	18
<b>Popn Hybrids</b>							
R678H5	Z325aa x R578(Sp)	12403	39.19	155	0.3	94.8	69
R678H11M	5911-4Maa x R578(Sp)	10894	34.45	141	0.3	93.5	36
R678H91-10	2891mA(Sp)-10aa x R578(Sp)	10762	34.06	149	0.0	93.4	35
R678H70	5869HO x R578(Sp)	10410	33.54	157	2.4	93.7	58
R678H67-1	2867mA(Sp)-1aa x R578(Sp)	10300	33.60	148	0.0	92.3	50
6931H21	5921H18aa x 931(C)	10275	33.90	146	1.8	91.7	32
6869H25	5925aa x 5869	10096	32.02	134	0.0	91.9	82
R678H59-8	2859mA(Sp)-8aa x R578(Sp)	10046	31.77	147	0.3	93.4	38
6835H18	RZM 4918aa x 835(C)	9986	32.59	138	0.0	91.9	69
Y671H25	5925aa x Y71(C)	9908	33.36	136	0.3	92.5	49
6921H25	5925aa x RZM-8S R21(C)	9676	32.17	148	1.5	91.4	61
6869H11M	5911-4Maa x 5869	9301	30.02	137	0.3	92.4	49
6835H11M	RZM 4911-4Maa x 835(C)	9056	30.00	144	0.0	91.6	63
Mean		10052.2	32.57	146.9	0.5	92.6	50.3
LSD (.05)		979.7	2.65	12.4	1.0	1.4	32.5
C.V. (%)		9.8	8.22	8.5	215.2	1.6	65.2
F value		12.3**	10.68**	3.6**	4.4**	4.8**	2.3NS

Note: See Test B497, et al. Z325 is similar to CZ25 being released in 1997.

TEST B1097. EVALUATION OF HYBRIDS UNDER MODERATE RHIZOMANIA,  
IMPERIAL VALLEY, CA., 1996-97

12 entries x 8 replications, RCB (equalized)  
1-row plots, 18 ft. long

Planted: September 11, 1996  
Harvested: May 19, 1997

Variety	Description	Acre Yield		Beets/ 100'	Bolters %	Clean Beets %	NO3-N Mean
		Sugar	Beets				
		Lbs	Tons				
<b>Checks</b>							
4006R	Betaseed, 2/8/96	8955	31.16	142	0.0	90.8	127
Rival	HH103(1031203), 8/29/95	8569	30.65	130	3.3	93.4	358
SS-781R	Spreckels(941000), 2/28/95	7562	31.17	124	1.2	93.1	259
<b>Experimental Hybrids</b>							
R522H50	F92-790-15CMS x C51	8863	35.35	141	9.5	92.6	360
R678H50	F92-790-15CMS x R578 (Sp)	8847	33.54	147	0.0	92.9	242
R678H70	5869HO x R578 (Sp)	8674	34.79	138	1.0	93.6	227
Y671H50	F92-790-15CMS x Y71 (C)	8660	33.26	140	1.1	93.3	179
R678H11M	5911-4Maa x R578 (Sp)	8293	35.61	140	0.0	93.1	290
R678H88	5890HO x R578 (Sp)	8146	31.65	142	1.4	92.9	168
6921H50	F92-790-15CMS x RZM-8S R21 (C)	8012	31.41	139	5.3	91.0	248
Y671H25	5925aa x Y71 (C)	7888	32.70	121	0.7	91.5	274
6921H25	5925aa x RZM-8S R21 (C)	6791	27.08	114	5.5	93.1	237
Mean		8271.7	32.37	134.8	2.4	92.6	247.
LSD (.05)		1188.5	4.47	16.9	4.3	1.9	96.
C.V. (%)		14.4	13.87	12.6	179.5	2.0	39.
F value		2.3*	2.27*	2.8**	3.7**	2.0*	4

TEST B697. AREA 5 CODED RHIZOMANIA YIELD TEST, IMPERIAL VALLEY, CA., 1996-97

32 entries x 8 replications, RCB (equalized)  
1-row plots, 27 ft. long

Planted: September 13, 1996  
Harvested: May 21, 1997

Code	Variety	Source	Acre Yield		Sucrose %	Beets/ 100'	Bolters		Clean		NO3-N Mean
			Sugar Lb	Beets Tons			%	%	Beets	%	
13	Rizor	Spreckels	11535	34.80	16.59	166	0.6		93.6		57
19	4KJ0164	Betaseed	11340	35.15	16.11	156	0.0		91.6		69
18	H93778	Spreckels	11272	35.95	15.71	163	0.0		93.8		44
11	BETA 4776R	Betaseed	11260	33.20	17.03	156	0.0		93.3		49
22	Rival	Spreckels	11063	32.33	17.11	152	0.5		94.2		40
8	BETA 4684R	Betaseed	10899	33.19	16.40	156	0.0		94.2		77
26	5CG7540	Betaseed	10889	33.02	16.51	135	0.0		91.3		66
15	BETA 4035R	Betaseed	10865	33.58	16.17	152	0.4		93.4		71
12	BETA 4006R	Betaseed	10858	32.56	16.75	161	0.2		91.3		42
4	SS-NB7R	Spreckels	10734	33.76	15.98	148	0.3		92.7		62
7	BETA 4581	Betaseed	10622	32.81	16.27	151	1.2		93.8		77
14	SS-IV2R	Spreckels	10552	33.11	15.96	163	0.0		92.4		58
28	SS-781R	Spreckels	10538	32.80	16.07	147	0.7		93.9		28
9	4KJ0169	Betaseed	10409	31.87	16.35	167	0.0		89.0		58
29	6921H50	USDA	10393	30.93	16.79	153	3.8		90.9		29
31	6913-70H37	USDA	10375	33.97	15.26	142	0.0		91.7		43
24	6CG7466	Betaseed	10374	32.98	15.75	133	0.0		92.8		40
2	6CG7464	Betaseed	10224	32.66	15.66	148	0.0		93.7		72
25	HM 3048	Hilleshog	10202	30.19	16.93	163	0.5		91.1		34
20	SS-694R	Spreckels	10132	31.62	16.02	145	0.3		92.3		28
30	R680H37	USDA	10049	32.27	15.56	145	0.0		92.3		44
1	HM 3058	Hilleshog	9988	30.72	16.18	165	0.0		92.8		68
6	HM 3059	Hilleshog	9987	31.36	15.89	148	19.5		91.9		50
21	H95786	Spreckels	9931	31.69	15.66	165	0.0		90.3		30

TEST B697. AREA 5 CODED RHIZOMANIA YIELD TEST, IMPERIAL VALLEY, CA., 1996-97

(cont.)

Code	Variety	Source	Acre Yield		Beets/ 100'	Bolters %	Clean Beets %	NO3-N Mean
			Sugar lb	Beets Tons				
5	HH-97R	Spreckels	9657	30.64	15.75	0.7	93.3	58
10	BETA 4684	Check	9555	30.71	15.58	0.0	90.9	45
3	6CG7417	Betaseed	9531	28.32	16.84	0.2	90.3	34
16	SS-IV2	Check	9057	31.05	14.66	0.0	90.7	67
27	Rhizoguard	Spreckels	8984	28.21	15.94	0.0	94.2	32
23	HM 3013	Check	8840	28.70	15.39	0.0	89.4	22
32	R522H50	USDA	7880	25.58	15.45	17.5	89.4	52
17	US H11	Check	7873	26.14	15.02	0.0	90.0	29
Mean			10183.4	31.75	16.04	1.5	92.1	49.2
LSD (.05)			1018.5	2.89	0.73	2.3	2.1	36.0
C.V. (%)			10.2	9.23	4.63	162.6	2.3	74.2
F value			6.2**	5.24**	5.06**	29.5**	4.4**	1.6*

(cont.)

Code	Variety	Recover.	Recover.	Recover.	Known	Sodium	Potassium	NH <sub>2</sub> -N	Impur.
		Sugar	Sugar	Sugar					
		lbs/a	lbs/t	%	lbs/a	ppm	ppm	ppm	
113	Rizor	10286	296	89.1	1249	427	2133	541	11967
119	4KJ0164	9963	283	87.8	1377	588	2181	582	13042
118	H93778	9931	277	88.1	1341	487	2356	509	12434
111	BETA 4776R	10129	307	90.0	1131	363	1819	561	11144
22	Rival	9960	308	90.0	1103	415	2092	497	11405
8									
26	5CG7540	9620	292	88.3	1270	540	2188	580	12869
115	BETA 4035R	9569	285	87.8	1296	462	2307	582	12913
12	BETA 4006R	9791	302	90.2	1066	439	1732	524	10848
4	SS-NB7R	9363	279	87.0	1371	495	2391	602	13423
7	BETA 4581	9320	286	87.6	1302	445	2205	631	13066
14	SS-IV2R	9250	280	87.6	1302	470	2124	638	13011
28	SS-781R	9396	286	89.1	1142	387	2102	531	11655
9	4KJ0169	9222	290	88.6	1186	379	2011	636	12398
29	6921H50	9395	303	90.3	998	385	2079	457	10882
31	6913-70H37	9091	267	87.5	1284	513	2453	498	12653
24	6CG7466	9304	282	89.7	1070	466	2081	427	10886
2	6CG7464	9018	277	88.4	1207	550	2167	508	12169
25	HM 3048	9241	307	90.6	962	399	1873	478	10620
20	SS-694R	9055	286	89.3	1078	413	2130	488	11410
30	R680H37	8799	273	87.6	1250	536	2537	487	12847
1	HM 3058	8925	289	89.0	1064	495	2159	476	11652
6	HM 3059	8954	285	89.5	1033	515	2114	414	11024
21	H95786	8913	281	89.8	1019	482	2220	363	10686

TEST B697. AREA 5 CODED RHIZOMANIA YIELD TEST, IMPERIAL VALLEY, CA., 1996-97

(cont.)

Code	Variety	Recover.		Recover.		Recover.		Known SugarLoss lbs/a	Sodium		Potassium		NH <sub>2</sub> -N ppm	Impur. Value
		Sugar lbs/a	Sugar lbs/t	%	Sugar lbs/a	Sugar ppm	Potassium ppm							
5	HH-97R	8606	281	89.0	1050	573	2049	450	11400					
10	BETA 4684	8430	276	88.4	1124	548	2146	495	11987					
3	6CG7417	8468	300	89.0	1063	399	2024	615	12297					
16	SS-IV2	7944	257	87.8	1114	639	2169	448	11911					
27	Rhizoguard	8070	286	89.9	914	485	2129	397	10789					
23	HM 3013	8036	280	91.0	804	487	1913	290	9245					
32	R522H50	6830	268	86.6	1051	483	2481	620	13780					
17	US H11	7009	268	89.1	864	398	2123	445	10932					
Mean		9047.0	285.2	88.8	1136.4	474.2	2144.8	511.3	11879.3					
LSD (.05)		961.3	17.0	1.8	192.8	124.7	185.1	109.7	1523.8					
C.V. (%)		10.8	6.1	2.1	17.2	26.7	8.8	21.8	13.0					
F value		5.6 **	4.1**	2.9**	4.6**	2.3**	7.1**	4.6**	3.5**					

NOTES: Mild rhizomania. Infection variable across field. Low nitrogen status. Off water about three weeks when harvested.

USDA entries: 6921H50 = C790-15CMS x R21 (25% Bvm); R680H37 = C306CMS x C80; 6913-70H37 = C306CMS x C913-70; R522H50 = C790-15CMS x C51 (50% Bvm). Relative performance of R522H50 suggests that rhizomania was mild.

TEST B897. EVALUATION OF LINES UNDER HIGH TEMPERATURE, RHIZOMANIA CONDITIONS  
IN A LATE HARVEST (GERMPLASM FROM C51), IMPERIAL VALLEY, CA., 1996-97

48 entries x 4 replications, sequential  
1-row plots, 18 ft. long

Planted: September 11, 1996  
Not harvested for yield

25 June 97

Variety	Description	Narrative Description	Stand Count		Plants at Living		RZM
			No.	No.	Harvest	%	
		16 May 97					Score
SS-781R	Spreckels (941000), 2/28/95	fair-good	27	23		60.9	2.5
4006R	Betaseed, 2/8/96	good	31	28		84.9	1.5
Rival	HH103 (1031203), 8/29/95	fair-good	28	25		88.0	1.8
Rizor	LF291, 2/13/96	fair-good	31	29		95.9	1.0
US H11	L113401, 11/16/94	fair, yellow	28	22		13.8	4.3
R522 (Sp)	RZM-%S R322R4, Y3 (C51)	good	28	19		96.6	0.5
R626	RZM R526 (UK-Em)	fair-good	28	20		84.2	2.0
R639	RZM R539 (C39R, quant.)	fair	27	21		78.7	1.8
R678 (Iso)	NB-RZM R478NB (C78)	poor-fair	30	22		31.7	3.8
R680NB (Iso)	NB-RZM R480NB (C80NB)	fair-good	28	21		48.2	3.0
R681	NB-RZM R481, R482, R484, (C82)	poor-fair	26	21		62.4	2.5
Y668	RZM Y568 (Y#rr x R#)	poor-fair	28	23		62.1	2.5
Y669 <sup>1</sup>	RZM Y569 (Y#rr x R#)	fair-good	30	24		61.0	2.5
R679	RZM R579 (Rz) (C79-1)	poor	29	22		43.9	3.5
R635	RZM R535gh (SES) (C79-7)	fair-good, seg.	28	23		67.0	2.3
R645	RZM R545, R532 (R04) (C79-5)	fair	29	23		39.7	3.3
R641	RZM R541, R548 (WB169) (C79-10)	fair-good, seg.	27	19		67.8	2.5
R642	RZM R542, R549 (WB258) (C79-11)	fair	28	23		47.7	3.0
R636	RZM R536 (R22, 12%) (C79-8)	good	28	21		72.5	2.3
R646	RZM R546 (R22, 6%)	good	27	20		83.3	1.8
R653	RZM 5243, P (R22, 3%)	fair-good, seg.	28	18		62.6	2.8
R643	RZM-%S R443 (R22, 12%)	fair-good, seg.	29	23		74.5	2.0
R640-1	RZM-%S R440-1 (C37 x PX)	fair-good, seg.	28	21		78.3	2.0
R651	RZM R551 (C37*2 x PX) (C79-#PX)	poor-fair, seg.	28	19		76.9	2.0
Y664	RZM Y564R (C37, C82, C78, C80xR22Y, 25%)	good, seg. 25%R	30	22		87.8	1.8
Y665	RZM Y565 [(C80, C82x(C37xR22, 6%)]	good, seg. 25%R	28	18		88.4	1.5
Y666	RZM Y566 (Y#rr x R22Y, 12%)	good, seg. 50%R	28	20		84.0	1.8
Y667 <sup>1</sup>	RZM Y567 (Y#rr x R22Y, 12%)	good, seg. 50%R	27	21		87.3	1.8
Y671	RZM 5205, 6, 7, 8 (C37, C82, C78, C80 x R22Y3, 12%)	good-v. good, resist.	29	20		89.7	1.5
Y672 <sup>1</sup>	RZM 5280, 5284 (C80, C82 x R22, 3%)	good, seg.	30	24		84.0	2.0

TEST B897. EVALUATION OF LINES UNDER HIGH TEMPERATURE, RHIZOMANIA CONDITIONS  
IN A LATE HARVEST (GERMPLASM FROM C51), IMPERIAL VALLEY, CA., 1996-97  
(cont.)

Variety	Description	Narrative Description	25 June 97			
			Stand Count		Plants at Living	
			No.	Harvest	Plants	RZM Score
		16 May 97		No.	%	
US H11	L113401, 11/16/94	poor-fair	29	25	40.6	3.5
R522 (Sp)	RZM-8S R322R4, Y3 (C51)	good, resist.	28	21	100.0	0.0
6931 (Sp)	931 (C)aa x A	poor-fair	26	22	70.1	2.3
6920	RZM 5920 (918aa x R22, 6%)	fair, few R	26	19	60.7	2.8
6921 (Iso)	RZM R522H18 (918aaxR22, 25%)	good, resist.	28	21	100.0	0.5
6922	RZM 5922 (918aa x C79PX)	poor-fair, few R	25	17	65.2	3.0
6923	RZM 5923 (918aa x C79PX)	fair, seg.	26	19	52.7	3.0
6927	RZM 5921H18 (918aa x R21, 12%)	good, resist.	29	18	88.7	1.3
6926	RZM 5287, P(918aa x R22, 3%)	poor-fair, 0%R	28	20	49.2	3.0
6931H21	5921H18 x 931 (C), 6%	good, seg.	26	16	77.4	2.5
6828m	RZM 5828-#'smm (911-4aa x CTRmm)	v. poor	29	23	35.2	3.3
6890	RZM 5890 (C890-1, Rz)	poor	27	22	49.7	3.0
6812M	RZM 5812M (C890-2/3, WB41/42)	poor	29	20	35.7	3.5
6815M	RZM 5815M (C890-5, R04)	poor-fair	29	24	54.8	3.0
6817M	RZM 5268M (C890-7, SES)	poor	30	24	43.2	3.5
6818M	RZM 5270, 2M (C890-8, R22)	poor-fair, few R	28	22	56.4	3.0
6869m	RZM 5869mm (867mmaa x C890-1)	poor	29	24	65.1	3.0
6929	RZM R581H11, ... (911-4aa x R81)	fair-good	28	24	70.6	2.5
Mean			28.0	21.4	67.1	2.4
ISD (.05)			4.0	4.1	19.7	0.7
C.V. (%)			10.3	13.6	21.0	22.2
F value			0.9NS	3.0**	8.3**	11.5**

<sup>1</sup>Y669 ≈ C69; Y667 ≈ C67; Y672 ≈ C72 released and distributed in 1997.

NOTES: RZM test visually scored on 25 June 1997 from 0 to 5, where:

0 = 100% alive and vigorous plot; 1 = good vigor and survival; 2 = reduced vigor and fewer alive;

3 = intermediate vigor and survival; 4 = poor, low vigor, most plants dead; 5 = 100% of plants dead.

Living plants (%) based upon actual counts of living vs. dead plants on 25 June 97 where living = any plant with green. Stand counts made in October 96 shortly after thinning. Seg. = segregating for vigor (reaction to rhizomania) where R = resistance similar to C51 (R22) type.



TEST B997. AREA 5 CODED SEVERE RHIZOMANIA YIELD TEST,  
IMPERIAL VALLEY, CA., 1996-97

30 entries x 8 replications, RCB  
1-row plots, 18 ft. long

Planted: September 11, 1996  
Not harvested for yield

Code No.	Variety	Source	Stand Count	25 June 97		
				Plants at Harvest	Living Plants	RZM Score
			No.	No.	%	
1	HM 3058	Hilleshog	25	21	70.3	2.3
2	6CG7464	Betaseed	24	18	18.2	3.9
3	6CG7417	Betaseed	25	22	80.0	2.1
4	SS-NB7R	Spreckels	23	19	58.9	2.5
5	HH-97R	Spreckels	24	19	70.8	2.1
6	HM 3059	Hilleshog	26	21	59.2	2.6
7	BETA 4581	Betaseed	26	23	80.4	1.9
8	BETA 4684R	Betaseed	25	21	72.3	2.1
9	4KJ0169	Betaseed	25	21	42.9	3.1
10	BETA 4684	Check	26	21	40.9	3.1
11	BETA 4776R	Betaseed	25	22	85.8	1.6
12	BETA 4006R	Betaseed	26	23	78.8	2.0
13	Rizor	Spreckels	25	22	82.0	1.8
14	SS-IV2R	Spreckels	24	20	71.0	2.3
15	BETA 4035R	Betaseed	26	19	73.7	2.1
16	SS-IV2	Check	26	21	53.9	2.8
17	US H11	Check	21	17	24.2	3.9
18	H93778	Spreckels	26	22	71.3	2.0
19	4KJ0164	Betaseed	23	20	72.3	2.1
20	SS-694R	Spreckels	24	21	63.5	2.4
21	H95786	Spreckels	25	20	60.0	2.4
22	Rival	Spreckels	23	21	89.4	1.8
23	HM 3013	Check	23	19	23.9	3.9
24	6CG7466	Betaseed	22	20	57.2	2.6
25	HM 3048	Hilleshog	23	19	73.7	2.1
26	5CG7540	Betaseed	24	23	88.6	1.4
27	Rhizoguard	Spreckels	27	20	74.4	2.3
28	SS-781R	Spreckels	27	23	69.1	2.1
29	6921H50	USDA	26	20	84.8	1.5
30	R522H50	USDA	19	16	95.9	0.3

TEST B997. AREA 5 CODED SEVERE RHIZOMANIA YIELD TEST,  
IMPERIAL VALLEY, CA., 1996-97

(cont.)

Code No.	Variety	Source	Stand Count	25 June 97		
				Plants at Harvest	Living Plants	RZM
			No.	No.	%	Score
Mean			24.4	20.5	66.3	2.3
LSD (.05)			4.1	3.6	16.3	0.7
C.V. (%)			16.9	18.0	25.0	29.4
F value			1.5*	1.7*	11.3**	10.1**

NOTES: RZM test visually scored on 25 June 1997 from 0 to 5, where:  
0 = 100% alive and vigorous plot; 1 = good vigor and survival;  
2 = reduced vigor and fewer alive; 3 = intermediate vigor and survival;  
4 = poor, low vigor, most plants dead; 5 = 100% of plants dead.

Test under severe rhizomania conditions, except for two rows which apparently were outside of the area where rhizomania infestation occurred. Because of severity and variability, test was judged not to be harvestable for yield data. Instead, it was rated and scored visually. Living plants (%) based upon actual counts of living vs. dead plants on 25 June 97, where living = any plant with green.

Stand counts made in October shortly after thinning.

CURLY TOP EVALUATION OF SALINAS ENTRIES at KIMBERLY, IDAHO, 1997

180 entries x 3 replications  
2-row plots, 12 ft. long

Planted: June 11 & 16, 1997  
Not harvested for yield

Variety	Description	Stand Count	CT <sup>1</sup> BSDF	CT <sup>2</sup> LP	CT <sup>3</sup> AC
		No.	late	9/11/97	9/04/97
<u>Planted 6-11-97 (late)</u>					
<u>Hybrids</u>					
US H11	F82-546H3 x C36, 113102	28	4.7	4.7	4.5
WS-PM9	Hilleshog-MH, 4-18-95	29	4.3	4.0	4.1
4454	Betaseed	26	5.0	5.3	5.7
Rival	HH103,L1032406,3-18-97	30	6.7	7.7	6.5
SS-781R	950659ZC, Spreckels	26	5.3	6.7	5.9
Monohikari	rec'd 2-18-97	27	7.3	8.3	7.3
B4776R	Betaseed 4776.6102	29	6.7	7.7	6.8
R678H5	(CZ25)Z325aa x R578 (C78)	26	5.3	5.7	5.3
R678H7	5911-4-7CMS x R578	25	4.7	5.0	5.1
R678H11	(C911-4)5911-4mmaa x R578	23	4.7	4.7	5.5
R678H39	91-762-17CMS x R578	24	4.0	3.0	3.7
R678H50	F92-790-15CMS x R578	29	4.0	4.0	4.4
R678H59	(C859)5859%aa x R578	29	4.0	4.3	4.9
R678H59-8	2859mA(Sp)-8aa x R578	23	4.3	4.3	4.9
R678H67-1	2867mA(Sp)-1aa x R578	24	4.3	4.0	5.0
R678H68	5867HO x R578	24	4.3	4.7	5.2
R678H70	5869HO x R578	26	4.3	4.3	5.0
R678H72	U83-718HO x R578	26	4.3	3.7	4.4
R678H87	(C890-1)5890aa x R578	27	4.7	4.7	5.1
R678H95	5895aa x R578	25	4.7	4.3	5.3
US H11	113102	26	4.7	4.3	5.0
R680H31-4	5831-4aa x RZM R580 (C80)	26	4.7	5.0	5.5
R680H37	4807HO(C306/2CMS) x RZM R580	29	4.0	4.7	5.4
R680H50	F92-790-15CMS x RZM R580	28	5.0	5.3	5.6
R680H70	5869HO x RZM R580	27	5.0	5.0	5.5
R680H88	5890HO x RZM R580	28	5.0	5.7	5.5
Y671H7	5911-4-7CMS x Y71(C)	23	4.7	5.3	5.6
Y671H15	5915aa x Y71(C)	26	4.7	5.0	5.6
Y671H25	5925aa x Y71(C)	27	5.0	5.7	6.0
Y671H37	4807HO(C306/2CMS) x Y71(C)	30	4.7	5.0	5.9
Y671H50	F92-790-15CMS x Y71(C)	26	5.0	5.3	6.0
US H11	113102	28	4.7	3.7	4.8
6911-4-10H50	F92-790-15CMS x RZM 4911-4-10	24	5.0	5.0	5.4
6913-70H50	F92-790-15CMSx5913-70(C913-70)	27	5.0	5.3	6.0
6915-7-6H50	F92-790-15CMS x RZM 4915-7-6	27	5.0	5.3	5.9
6918-3H50	F92-790-15CMS x RZM 4918-3	29	5.0	4.7	5.3
6918-12H50	F92-790-15CMS x RZM 4918-12	25	5.0	6.0	6.4
6918-21H50	F92-790-15CMS x RZM 4918-21	29	5.0	5.0	5.5
6921H50	F92-790-15CMS x RZM-%S R21(C)	26	5.0	5.0	5.5
6931H50	F92-790-15CMS x 931(C)	26	4.7	4.3	5.3

CURLY TOP EVALUATION OF SALINAS ENTRIES at KIMBERLY, IDAHO, 1997

(cont.)

Variety	Description	Stand Count	CT <sup>1</sup> BSDF	CT <sup>2</sup> LP	CT <sup>3</sup> AC
		No.	late	9/11/97	9/04/97
<u>Hybrids (cont.)</u>					
6931H21	5921H18aa x 931 (C)	24	4.7	5.0	5.5
6931H70	5869HO x 931 (C)	26	5.0	5.0	5.4
6931H88	5890HO x 931 (C)	25	5.0	5.7	5.7
6913-70H37	4807HO x 5913-70 (C913-70)	26	5.0	5.7	6.4
6913-70H39	91-762-17CMS x 5913-70	27	5.0	5.3	5.8
6913-70H70	5869HO x 5913-70	26	5.0	6.3	6.0
US H11	113102	31	4.7	5.0	5.4
WS-PM9	Hilleshog-MH, 4-18-95	28	4.3	4.7	4.7
6921H15	5915aa x RZM-%S R21 (C)	22	5.3	6.0	6.0
6921H25	5925aa x RZM-%S R21 (C)	25	5.0	5.0	5.9
R578H8	F92-546H3 x RZM R478NB (C78)	23	4.3	4.7	5.0
R578H76	4867-1H50 x RZM R478NB	26	5.0	5.3	5.5
<u>Multigerm, O.P. Lines</u>					
U86-46/2	C46,86342	22	5.3	6.0	6.3
R678 (Iso)	NB-RZM R478NB (C78)	23	5.0	5.7	6.0
R678 (Sp)	RZM R578	24	5.0	5.3	5.5
R678/2	RZM R578/2 (C78/2)	26	5.0	5.7	6.1
R639	RZM R539 (C39R)	21	5.3	6.3	6.3
R647	RZM R547 (C47R)	26	6.0	6.7	6.4
<u>Planting date mixed</u>					
R680 (Iso)	RZM R580	24	5.7	5.7	5.7
R680NB (Iso)	NB-RZM R480NB (C80NB)	27	5.7	5.3	5.5
R680-#	NB-RZM R480-45;-# (C80)	26	5.7	5.3	5.8
R680 (Sp)	RZM R580, R580NB, ...	20	5.7	5.7	6.0
R86-31/6	C31/6, 86263	19	5.7	7.0	6.5
R681	NB-RZM R484, R482NB, ...	27	5.3	5.7	5.8
<u>Planted 6-11-97 (early)</u>					
90-CT01	MM, O.P., CTR	25	4.7	4.3	5.0
90-CT02	MM, O.P., CTR	25	4.7	4.3	5.0
Y664	RZM Y564R	29	5.0	5.3	5.5
Y665	RZM Y565	24	5.0	5.7	5.6
Y666	RZM Y566	25	5.0	5.3	5.1
Y667	RZM Y567, (~C67)	25	5.0	4.7	4.9
Y668	RZM Y568	24	4.0	3.7	4.3
Y669	RZM Y569, (~C69)	30	4.0	4.3	5.0
Y671	RZM 5205, P; ...	28	4.3	4.3	5.3
Y672	RZM 5280, P; ..., (~C72)	29	4.3	4.3	4.9
US H11	113102	29	4.0	3.0	3.8
U86-37	C37, 86443	21	4.0	3.7	4.5
R679	RZM R579 (C79-1, Rz)	22	4.0	4.0	4.8
R636	RZM R536 (C79-8, R22)	26	4.0	3.7	4.7
R646	RZM R546	30	4.7	4.7	4.8
R653	RZM 5243, P	25	4.0	4.3	5.1

CURLY TOP EVALUATION OF SALINAS ENTRIES at KIMBERLY, IDAHO, 1997

(cont.)

Variety	Description	Stand	CT <sup>1</sup>	CT <sup>2</sup>	CT <sup>3</sup>
		Count	BSDF	LP	AC
		No.	late	9/11/97	9/04/97
<b>Multigerm, O.P. Lines (cont.)</b>					
R635	RZM R535(gh) (C79-7, SES)	27	4.3	5.3	5.2
R637	RZM R537, R550 (C79-9, WB151)	29	4.0	3.7	4.3
R641	RZM R541, R548 (C79-10, WB169)	28	4.0	3.3	4.1
R642	RZMR542, R549 (C79-11, WB258)	27	4.0	3.7	4.4
R645	RZM R545, R532 (C79-5, R04)	27	4.0	3.7	4.4
R640	RZM R540% (Iso)	27	4.3	4.0	4.5
R640-1	RZM-%S R440-1, R540-1	27	4.3	4.3	5.0
R651	RZM R551	24	4.0	3.7	4.1
R626	RZM R526	25	5.0	3.7	5.3
U86-37	C37, 86443	22	4.0	4.0	4.5
P603	PMR P403 (WB97)	28	4.0	2.7	3.7
P604	PMR P404 (WB242)	28	3.7	3.3	4.0
R643	RZM-%S R443	27	4.0	4.3	5.2
R522 (Sp)	RZM-%S R22 (C) (C51)	23	4.3	4.3	5.0
US H11	113102	28	4.0	3.7	3.7
WS-PM9	Hilleshog-MH, 4-18-95	26	4.0	3.0	3.4
<b>Multigerm, S<sup>f</sup>, Aa Populations</b>					
N621	NR-RZM N521, N522	27	4.0	4.0	4.2
N627	NR-RZM N527, N528	24	4.3	3.3	4.4
P601	PMR P401 (WB97, 242)	25	4.3	3.7	4.5
P602NR	NR-P202 (WB242)	21	4.7	4.3	4.5
R609	CR-RZM R409 (CR09)	19	4.7	4.7	4.7
R609R2	CR-RZM R409R2	20	5.7	5.7	5.5
R610	CR-RZMR410 (CR10)	25	5.0	5.0	5.2
R610R2	Cr-RZMR410R2	25	5.0	5.0	5.1
6259CMS-# (C)	5263CMSx 5262A (37%CTR)	23	4.0	2.3	3.0
6260-6261-# (C)	5262aa x 5263 (37%CTR)	20	4.0	3.3	3.7
6262-#A (C)	5262A⊗ (25%CTR)	23	4.3	3.7	4.0
6263-#A (C)	5263A⊗ (50%CTR)	22	4.3	4.3	4.3
6264-# (C)	4918aa x 5264CMS-PF (RAR)	24	4.7	4.7	5.3
6931	5915, 5925, ...aa x A	23	5.0	4.3	4.9
6911-4-7	RZM 5911-5-7mm	23	4.7	4.7	4.7
6911-4-10	RZM 4911-4-10	19	4.7	4.7	4.7
6913-70 (Iso)	RZM 5913-70 (C913-70)	31	5.3	6.0	6.3
6913-70 (Sp)	5913-70aa x A (C913-70)	26	5.0	6.3	6.1
6915-7-6	RZM 4915-7-6	26	5.0	5.0	5.4
6918-3	RZM 4918-3	24	4.7	4.7	4.8
6918-12	RZM 4918-12	24	5.0	6.3	6.0
6915	NB-RZM 4915, ...	26	4.7	4.3	4.6
6925	YR 4909-#, ...	25	4.7	4.3	4.8
6920	RZM 5920	24	5.0	5.0	5.4

CURLY TOP EVALUATION OF SALINAS ENTRIES at KIMBERLY, IDAHO, 1997

(cont.)

Variety	Description	Stand Count	CT <sup>1</sup> BSDF	CT <sup>2</sup> LP	CT <sup>3</sup> AC
		No.	late	9/11/97	9/04/97
<u>Multigerm, S<sup>f</sup>, Aa Populations (cont.)</u>					
6921	RZM R522H18	25	5.0	5.7	5.4
6921 (Sp)	RZM-%S R21 (C)	26	5.0	5.3	5.2
6922	RZM 5922	22	5.0	5.3	5.3
6923	RZM 5923	27	4.7	5.3	5.7
WS-PM9	Hilleshog-MH, 4-18-95	28	4.0	3.3	3.5
6924	RZM 5924	27	5.0	5.0	5.5
6929	RZM R581H11,...	28	5.0	5.3	5.5
6930	RZM R578H11,...	28	4.7	5.0	5.2
6926	RZM 5287, P	27	4.7	5.0	5.3
6927	RZM 5921H18	28	4.7	4.7	4.9
6931	5915, 5925, ...aa x A	24	4.7	5.0	5.0
US H11	113102	25	4.3	3.3	4.6
<u>Monogerm, S<sup>f</sup>, Aa Populations &amp; Lines</u>					
6835H11	4911-4mmaa x 835 (C)	18	4.7	4.3	5.5
6835H18	RZM 4918aa x 835 (C)	22	4.3	4.7	5.1
6869H11	5911-4mmaa x 5869	20	4.7	5.7	5.7
6869H15	5915aa x 5869	25	4.7	4.7	5.2
6869H25	5925aa x 5869	25	4.7	4.7	5.1
<u>Planting date mixed</u>					
6869m	RZM 5869mm	25	4.7	5.0	5.0
6869	5869mmaa x A	25	4.7	5.0	5.0
6890 (Iso)	RZM 5890 (C890-1, Rz)	28	4.7	5.0	5.1
6808m	0790mmaa x 808 (C)	21	4.3	4.3	5.1
6812M	RZM 5812M (C890-2/3, WB41/42)	17	5.0	4.7	5.3
6814M	RZM 5814M (C890-4, PI07)	25	5.0	5.3	5.5
6815M	RZM 5815M (C890-5, R04)	25	4.7	5.3	5.4
<u>Planted 6-16-97</u>					
6816M	RZM 5277M (C890-6, R05)	24	4.7	4.7	5.1
6817M	RZM 5268M (C890-7, SES)	25	4.7	5.3	5.5
6818M	RZM 5270, 72 (C890-8, R22)	27	5.0	4.7	5.0
6819M	RZM 5819M (C890-9, WB151)	26	5.7	6.0	6.5
6920M	RZM 5278M (C890-10, WB169)	26	5.0	5.7	5.6
6812M	RZM 5279M (C890-11, WB258)	27	5.7	6.3	6.4
6546	Inc. F82-546 (C546)	27	5.7	6.3	5.9
6562	Inc. F82-562 (C562)	20	4.7	4.7	5.3
6718	Inc. U83-718 (C718)	22	4.7	4.3	5.0
6762-17	Inc. 0762-17 (C762-17)	27	4.3	3.3	4.4
6796-43	Inc. 0796-43 (C796-43)	20	5.0	5.3	5.6
6828m	RZM 5828-3, -6, -12, -13mm	25	5.0	5.7	5.7
6831-4	RZM, T-O sel, 4831-4mm	16	5.7	5.7	5.9
6836M	RZM 5911-4-#, 5829-#, ...	26	6.0	6.7	6.2
6837m	T-O, RZM 5911-4-#, 5829-#, ...	21	5.3	6.3	5.7
6833m	RZM 5833-#'s (C)mm	22	4.7	4.3	5.1

CURLY TOP EVALUATION OF SALINAS ENTRIES at KIMBERLY, IDAHO, 1997

(cont.)

Variety	Description	Stand	CT <sup>1</sup>	CT <sup>2</sup>	CT <sup>3</sup>
		Count	BSDF	LP	AC
		No.	late	9/11/97	9/04/97
<u>Monogerm, S<sup>f</sup>, Aa Populations &amp; Lines (cont.)</u>					
6833%M	RZM-%S 4833%M	26	5.0	5.7	5.3
6834%M	RZM-%S 4834%mm	31	4.7	5.3	5.2
6859-8M	Inc. 2859MA (Sp) -8	26	5.3	5.3	5.5
4867-1	Inc. 2867mA (Sp) -1	27	5.0	4.7	5.2
6835H67	RZM 5867Nbmmaa x 835 (C)	23	5.0	5.7	5.7
6835H69	5869mmaa x 835 (C)	24	4.7	5.0	5.0
6835H34	RZM 5834mmaa x 835 (C)	27	4.7	5.0	5.3
6835H93M	RZM 5893Maa x 835 (C)	24	4.7	5.3	5.6
5890	3890-S <sub>1</sub> (C) mmaa x A (C890-1)	20	5.3	5.7	5.9
6546	Inc. F82-546 (C546)	22	5.3	5.0	5.9
6562	Inc. F82-562 (C563)	19	4.7	5.0	5.6
6762-17	Inc. 0762-17 (C762-17)	20	4.0	4.0	4.1
6867-1-3	4867-1-3mm⊗	17	5.3	6.7	6.2
6867-1-4	4867-1-4mm⊗	17	5.3	6.0	5.9
6867-1-5	4867-1-5mm⊗	8	6.0	7.0	7.0
6911-4-15	5911-4-15mm⊗	25	6.0	6.7	6.3
6930-11	RZM R578H16⊗	22	6.0	7.0	6.4
6930-31	RZM R578H19⊗	21	6.0	6.7	6.5
6930-51	RZM R578H18⊗	21	5.0	5.7	5.9
6930-111	RZM 5216M⊗	19	5.7	6.0	5.6

NOTES: This nursery had two planting dates because of rain. Most entries were not split between the two dates, but some were. Late planted plots appeared to be more severely damaged by curly top. No adjustments were made for these data. Entries 1-58 and 145-180 were planted late (6-16-97). Entries 65-138 were planted early (6-11-97). Entries 59-64 and 139-144 were split. Comparisons within planting dates should be representative of reaction to curly top.

<sup>1</sup>Scored by BSDF.

<sup>2</sup>Scored by Dr. Lee Panella.

<sup>3</sup>Scored by American Crystal Staff, Nampa, ID.

TEST 197. NONBOLTING EVALUATION OF MULTITERM LINES & POPULATIONS, SALINAS, CA., 1996-97

128 entries x 3 replications, sequential  
1-row plots, 26 ft. long

Planted: November 13, 1996  
Not harvested for yield

Variety	Description	Beets/ 100'	% Bolting				Powdery Mildew			Downey Mildew	
			No.	07/02	08/13	09/17	07/08	07/30	Mean	%infect	
MM,O.P.											
SP7622-O 268 U86-37 US H11	L80466 (8/87) (SP22-0)	74	20.5	24.0	32.7	1.0	6.3	3.7	0.7		
	Inc. 768 (US 75)	113	0.0	1.1	1.1	1.0	6.3	3.7	0.0		
	C37, L86443	86	0.0	0.0	0.0	1.7	6.7	4.2	0.0		
	L111102 (9-24-96)	115	0.0	1.1	1.1	1.7	7.0	4.3	0.3		
U86-46/2 R478NB R578 (Sp) R678 (Sp)	Inc. C46/2, 86342	109	0.0	0.0	0.0	0.0	6.0	3.0	0.0		
	NB R278,Y	81	0.0	3.3	6.2	0.0	6.3	3.2	1.3		
	RZM R478NB (C78)	115	0.0	0.0	0.0	0.0	5.7	2.8	1.7		
	RZM R578 (Sp) (C78)	115	1.1	4.4	4.4	0.7	6.0	3.3	1.0		
R678 (Iso) R578/2 R678/2 R578*	NB-RZM R478NB	122	0.0	0.0	0.0	0.3	6.0	3.2	0.3		
	NB-ER-RZM R378,Y	114	0.0	1.1	3.3	0.3	5.0	2.7	0.7		
	RZM R578/2 (C78/2)	128	0.0	0.0	0.0	0.0	4.7	2.3	0.3		
	RZM-%S R378 (Sp)	121	0.0	5.7	5.7	0.0	5.3	2.7	2.7		
R678H5 R678H11M R539 R639	Z325aa x R578 (Sp)	114	0.0	0.0	0.0	0.0	5.7	2.8	0.0		
	4911-4Maa x R578 (Sp)	122	0.0	0.0	0.0	0.3	5.3	2.8	0.0		
	NB-ER-RZM R139C7	108	0.0	3.6	4.8	1.0	5.3	3.2	1.0		
	RZM R539 (C39R)	118	4.3	13.0	18.3	1.0	5.3	3.2	0.3		
R547 R647 R570 R480NB	NB-ER-RZM R147C7	100	0.0	0.0	0.0	0.0	5.3	2.7	0.3		
	RZM R547 (C47R)	119	0.0	1.0	2.3	0.0	5.0	2.5	0.3		
	NB-ER-RZM R370	131	0.9	0.9	0.9	0.0	5.7	2.8	0.7		
	NB R280,Y	123	0.0	0.0	0.0	0.7	5.7	3.2	0.7		
R680NB (Iso) R580 R680 (Iso) R580NB	NB-RZM R480NB	117	0.0	0.0	0.0	0.7	6.3	3.5	1.3		
	NB-ER-RZM R380,Y	121	0.0	0.0	4.7	0.0	5.3	2.7	0.0		
	RZM R580	126	0.0	0.0	0.0	0.0	5.7	2.8	0.3		
	RZM R480NB	112	0.0	0.0	0.0	0.0	6.7	3.3	1.3		



(cont.)

Variety	Description	Beets/ 100'	% Bolting			Powdery Mildew			Downey Mildew %infect
			No.	07/02	08/13	09/17	07/08	07/30	
MM, O. P. (cont.)									
R680 (Sp)	RZM R580, R580NB, %, -#	104	0.0	1.5	1.5	0.3	6.7	3.5	0.3
R580%	RZM-%S R380 (Sp)	99	3.6	5.1	8.1	0.7	6.7	3.7	1.3
R580-#	RZM R480-# (C80)	119	1.1	1.1	3.0	0.3	6.0	3.2	1.0
R580-45	RZM R480-45 (C80-45)	117	0.0	0.0	0.0	0.3	6.3	3.3	0.3
R680-#	NB-RZM R480-45, -#	113	0.0	1.1	4.3	0.0	5.3	2.7	0.0
F86-31/6	Inc. C31/6, L86263	99	0.0	0.0	1.2	0.3	5.7	3.0	1.3
R482NB	NB R276-43, -89	121	0.0	2.0	4.1	0.3	4.0	2.2	0.3
R484	RZM R384	114	1.1	2.3	2.3	0.0	5.3	2.7	0.3
R576	NB-ER-RZM R376, Y	115	1.1	1.1	2.3	0.3	5.3	2.8	0.3
R581 (Sp)	RZM R481-43, -89	128	6.1	12.1	23.2	0.3	4.7	2.5	1.0
R681	NB-RZM R481-43, -89; ...	129	0.0	0.0	0.0	0.0	5.3	2.7	0.7
R576-89-18 (Sp)	Inc. R476-89-18	115	0.0	1.1	1.1	1.0	5.0	3.0	0.7
Y562	RZM Y462, R; Inc. Y462R	117	1.0	7.5	7.5	0.3	5.7	3.0	0.7
Y662	RZM Y562R	121	3.3	6.5	9.8	0.0	5.0	2.5	2.0
Y563	RZM Y463	112	2.2	3.2	4.5	0.0	5.0	2.5	0.7
Y663	RZM Y563R	114	4.6	7.0	7.0	0.3	6.0	3.2	0.7
Y668	RZM Y568	114	0.0	1.1	2.3	0.3	6.3	3.3	0.3
Y669	RZM Y569	117	2.2	4.3	8.8	0.3	5.3	2.8	1.7
Y522Y4	RZM-%S R322Y3, %	118	8.9	10.9	12.1	0.3	5.7	3.0	0.3
R522R5	RZM-%S R422R4, R4%	128	40.9	42.0	48.2	2.3	8.0	5.2	0.0
R522 (Sp)	RZM R422R4; R322Y3; ... (C51)	112	26.6	34.2	35.4	2.3	7.7	5.0	0.3
R626	RZM R526, F <sub>3</sub> (C37 x UK-Bvm)	115	45.6	55.6	55.6	2.3	7.0	4.7	1.7
U86-37	Inc. C37, L86443	99	0.0	0.0	1.2	0.3	6.7	3.5	0.3
SP 7622-0	L80466 (8/89)	101	35.6	36.8	36.8	1.0	6.3	3.7	1.0

TEST 197. NONBOLTING EVALUATION OF MULTIGERM LINES & POPULATIONS, SALINAS, CA., 1996-97

(cont.)

Variety	Description	Beets/ 100'	% Bolting				Powdery Mildew		Downey Mildew	
			No.	07/02	08/13	09/17	07/08	07/30	Mean	%infect
MM,O.P. (cont.)										
Y664	RZM Y564R	117		0.0	6.3	11.1	0.7	5.7	3.2	1.0
Y665	RZM Y565	136		1.7	6.0	9.5	1.3	5.3	3.3	0.7
Y666	RZM Y566	129		4.0	14.0	20.9	0.7	5.7	3.2	0.0
Y667	RZM Y567	117		2.7	5.4	6.4	0.3	5.0	2.7	0.0
Y671	RZM 5205,P;...	128		1.9	7.0	9.1	1.3	6.7	4.0	2.0
Y671 (Iso)	RZM 5205,P;...	121		3.2	5.3	10.6	1.7	6.3	4.0	2.3
Y671 (Sp)	RZM 5205,P;...	141		5.5	7.3	10.0	1.0	6.3	3.7	0.3
Y672	RZM 5280,P;5284,P	140		0.0	2.9	2.9	1.0	6.3	3.7	1.0
Y671H15	5915aa x Y71 (C)	114		2.2	4.5	5.7	1.0	6.0	3.5	0.7
Y671H25	5925aa x Y71 (C)	123		1.1	1.1	1.1	1.0	5.7	3.3	1.3
Y673	U86-37rr x Y71 (C)	127		1.1	1.1	3.2	0.7	6.7	3.7	0.0
R640	RZM R540%(Iso)	132		5.4	6.3	9.7	2.3	7.3	4.8	0.3
R640-1	RZM-%S R440-1	113		1.1	3.3	4.6	2.3	7.3	4.8	0.0
R651	RZM R551	128		2.0	3.1	4.1	1.7	7.3	4.5	0.0
US H11	L113401	135		0.0	1.0	1.0	0.3	6.3	3.3	0.0
R643	RZM-%S R443	132		17.0	17.0	20.9	2.0	7.0	4.5	1.0
U86-37	Inc. C37, L86443	86		0.0	0.0	0.0	1.0	6.7	3.8	0.3
RR679	RZM R579(C79-1)	114		4.4	11.2	11.2	1.3	6.0	3.7	1.0
RR635	RZM R535(C79-7)	118		0.0	2.5	2.5	1.0	6.3	3.7	1.0
RR637	RZM R537, R550(C79-9)	118		3.3	5.4	6.5	1.0	6.3	3.7	0.3
RR641	RZM R541,R548(C79-10)	115		1.0	2.1	2.1	2.0	7.3	4.7	0.0
RR642	RZM R542,R549(C79-11)	121		3.2	7.6	8.7	2.0	6.7	4.3	0.7
RR645	RZM R545,R542(C79-5)	123		8.9	13.5	16.8	0.7	7.0	3.8	1.0
RR636	RZM R536(C79-8)	114		5.3	6.5	7.6	3.3	8.7	6.0	0.0
RR646	RZM R546	112		1.1	2.3	3.4	2.7	7.7	5.2	1.7
RR653	RZM 5243,P	118		1.3	2.4	3.3	1.7	6.7	4.2	1.7

(cont.)

Variety	Description	Beets/ 100'	% Bolting			Powdery Mildew			Downey Mildew	
			07/02	08/13	09/17	07/08	07/30	Mean	%infect	
MM,S <sup>f</sup> ,Aa Populations										
R609	CR-RZM R409(CR09)	121	3.8	4.7	5.6	0.7	5.3	3.0		1.0
R609R2	CR-RZM R409R2	135	0.0	3.9	3.9	1.0	6.3	3.7		0.0
R610	CR-RZM R410(CR10)	118	1.0	5.0	5.9	0.0	5.7	2.8		1.0
R610R2	CR-RZM R410R2	115	21.2	26.1	26.1	0.7	6.3	3.5		0.0
N621	NR-RZM N521,N522	119	3.2	3.2	5.3	0.3	5.3	2.8		0.3
N627	NR-RZM N527,N528	127	0.9	0.9	0.9	0.3	6.3	3.3		0.3
N661	NR-RZM N561,...,N564	115	0.0	0.0	1.1	0.3	5.3	2.8		0.7
P601	PMR P401	127	18.8	23.7	25.5	0.3	4.3	2.3		0.0
P602NR	NR P202	131	38.7	38.7	38.7	0.0	4.3	2.2		0.0
P603	PMR P403	124	2.7	4.5	6.3	0.0	4.0	2.0		0.0
P604	PMR P404	131	7.1	19.4	23.3	0.0	5.7	2.8		0.0
4915(Sp)	3915,3911aa x A	127	4.1	4.2	4.2	0.7	5.3	3.0		2.0
4918	RZM 3918aa x A(C918)	131	1.0	4.9	4.9	0.0	5.3	2.7		0.0
5915(Sp)	RZM 4911,4915,4918aa x A	154	0.0	3.3	4.1	0.7	5.7	3.2		0.3
6915	NB-RZM 4911,M	118	0.0	0.0	1.4	0.7	5.0	2.8		0.0
5925	S <sub>1</sub> (MM,A:aa,Rz) (C)aa x A	117	1.1	3.3	5.7	0.0	5.3	2.7		0.3
6925	YR-%S (Davis) 4909...# (C)	122	0.0	0.0	0.0	0.0	5.0	2.5		2.0
6931	5915aa,...,aa x A(S <sub>1</sub> )	118	0.0	1.1	1.1	0.3	5.7	3.0		0.7
6931A	RZM S <sub>1</sub> (C)A	110	2.3	3.5	5.7	0.0	5.0	2.5		0.3
5924	RZM 4918aa x Y-#rr(C1)	118	2.3	4.4	6.4	0.3	5.7	3.0		0.3
6924	RZM 5924	115	1.1	1.1	1.1	0.3	4.7	2.5		0.3
6929	RZM R581H11,H18,...	118	0.9	0.9	3.1	0.7	6.0	3.3		1.0
6930	RZM R578H11,H16,...	106	0.0	1.3	2.7	0.7	5.3	3.0		0.0
6931H21	5921H18 x 931(C)	117	5.5	5.5	5.5	0.3	4.3	2.3		0.3

TEST 197. NONBOLTING EVALUATION OF MULTIGERM LINES & POPULATIONS, SALINAS, CA., 1996-97

(cont.)

Variety	Description	Beets/ 100'	% Bolting				Powdery Mildew		Downey Mildew %infect	
			No.	07/02	08/13	09/17	07/08	07/30		Mean
MM,S <sup>f</sup> ,Aa Populations (cont.)										
5920	RZM 4287	112		0.0	0.0	1.1	0.0	6.0	3.0	0.0
6920	RZM 5920	109		1.0	3.1	3.1	0.7	5.3	3.0	0.0
R544R2	RZM R444	126		0.9	2.0	3.0	0.7	6.7	3.7	0.7
5921H50	F92-790-15CMS x RZM R422Y3H15	121		6.4	8.5	8.5	1.0	6.0	3.5	0.3
5921 (Sp)	RZM R422Y3H15,...	117		14.6	16.8	19.1	0.7	7.0	3.8	0.3
5921H18	RZM 4918aa R21 (C)	124		2.1	6.1	7.2	0.7	6.7	3.7	1.0
6921	RZM R522H18	122		8.3	10.5	13.6	0.7	7.0	3.8	1.0
6921 (Sp)	RZM-%S R21 (C)	126		11.0	16.0	20.4	1.7	7.0	4.3	2.7
6921H15	5921aa x RZM-%S R21 (C)	127		3.7	7.4	9.7	0.0	5.7	2.8	0.3
6921H25	5925aa x RZM-%S R21 (C)	117		4.4	4.4	6.5	1.0	6.3	3.7	0.3
6926	RZM 5287,P	129		0.0	1.0	1.9	0.7	5.3	3.0	0.0
6927	RZM 5921H18	131		4.9	6.7	8.7	1.0	6.0	3.5	2.7
5922	RZM R440H18	136		1.8	4.6	4.6	0.7	6.3	3.5	0.3
6922	RZM 5922	114		0.0	2.2	4.6	0.7	6.3	3.5	0.7
5923	4918aa x R40 (C)	124		1.1	3.3	5.5	1.0	6.3	3.7	0.3
6923	RZM 5923	137		5.1	6.8	10.3	0.3	5.3	2.8	0.3
5913-71	RZM 4913-71	131		0.0	0.0	0.0	0.3	6.0	3.2	1.3
5913-70	RZM 4913-70 (C913-70)	136		0.0	0.0	0.0	0.0	5.0	2.5	0.0
6913-70 (Iso)	RZM 5913-70 (C913-70)	135		0.0	0.0	0.0	0.0	6.0	3.0	3.7
6913-70 (Sp)	RZM 5913-70aa x A (C913-70)	127		0.0	0.0	0.9	0.0	5.3	2.7	1.7
6913-70A (Sp)	RZM 5913-70A (C913-70)	140		0.0	0.0	0.0	0.0	5.3	2.7	0.0
5911-4-7	T-O-Sel. 4911-4-7mm	127		0.0	0.0	0.0	0.0	5.0	2.5	0.7

(cont.)

Variety	Description	Beets/ 100'	% Bolting			Powdery Mildew		Downey Mildew		
			No.	07/02	08/13	09/17	07/08	07/30	Mean	%infect
<u>MM,S<sup>f</sup>,Aa Populations (cont.)</u>										
6911-4-7m	RZM 5911-4-7	123	0.0	0.0	0.0	0.0	0.3	4.0	2.2	0.7
6911-4-7Homm	5911-4-7CMS x RZM 5911-4-7	106	0.0	2.4	3.7	0.0	0.0	4.7	2.3	0.7
6911-4-10	RZM 5911-4-10	94	0.0	0.0	0.0	0.0	0.0	4.0	2.0	1.3
6915-7-6	RZM 4915-7-6	115	0.0	2.6	2.6	0.0	0.0	4.0	2.0	0.0
6918-3	RZM 4918-3	97	0.0	0.0	0.0	0.0	0.0	4.3	2.2	0.0
6918-12	RZM 4918-12	94	0.0	0.0	0.0	0.0	0.0	3.3	1.7	0.0
5911-4 (Iso)	NB-ER-RZM 3911-4 (C911-4)	110	0.0	0.0	0.0	0.0	0.0	4.7	2.3	0.0
5911-4mA	RZM 4911-4mA	96	0.0	1.4	1.4	1.4	0.0	5.0	2.5	0.3
Mean		118.3	3.67	5.55	6.90	0.63	5.81	3.22	0.65	
LSD (.05)		22.3	6.23	8.11	9.17	1.05	1.12	0.85	1.54	
C.V. (%)		11.7	105.52	90.89	82.62	103.43	11.99	16.40	146.73	
F value		2.3**	12.86**	9.62**	8.78**	3.34**	5.13**	5.94**	1.59**	

NOTE: Winter of 1996-97 was warmer than normal and little induction for bolting occurred. Normally SP22-0 (SP7622-0) would bolt near 100%. Downy mildew had moderate incidence and infected plants were counted; actual incidence through course of season would have been higher than these counts indicate.

TEST 297. NONBOLTING EVALUATION OF MONOGERM LINES & POPULATIONS, SALINAS, CA., 1996-97

64 entries x 3 replications, systematic  
1-row plots, 26 ft. long

Planted: November 13, 1996  
Not harvested for yield

Variety	Description	Beets/ 100'	% Bolting				Powdery Mildew			Downey Mildew	
			07/02	08/13	09/17	07/08	07/15	07/25	Mean	%infect	%infect
6562	Inc. F82-562 (C562)	83	0.0	3.2	3.2	2.3	3.0	4.7	3.3	0.7	0.7
6546	Inc. F82-546 (C546)	119	2.1	2.1	1.3	3.7	4.0	6.7	4.8	2.7	2.7
6718	Inc. U83-718 (C718)	108	0.0	0.0	0.0	2.0	2.0	4.3	2.8	1.0	1.0
6762-17	Inc. 0762-17 (C762-17)	94	0.0	0.0	1.4	1.0	1.7	3.3	2.0	1.7	1.7
6796-43	Inc. 0796-43 (C796-43)	100	1.2	1.2	1.2	3.0	3.7	5.3	4.0	0.3	0.3
6835H18	RZM 4918aa x 835 (C)	117	0.0	1.2	3.1	2.3	2.3	6.0	3.6	0.7	0.7
6835H11	4911-4mmaa x 835 (C)	106	0.0	0.4	0.0	2.3	1.3	4.3	2.7	0.0	0.0
6835H11M	RZM 4911-4Maa x 835 (C)	137	1.0	1.0	1.0	2.7	2.0	5.7	3.4	0.3	0.3
6835H10	5810mmaa x 835 (C)	129	0.0	0.0	1.1	3.3	2.3	5.3	3.7	0.0	0.0
6835H10M	5810Maa x 835 (C)	113	0.0	1.1	1.1	3.0	2.7	6.0	3.9	0.7	0.7
6835H69	5869mmaa x 835 (C)	124	0.0	1.1	1.1	3.0	2.7	5.3	3.7	0.0	0.0
6835H67	RZM 5867NBmmaa x 835 (C)	127	4.2	2.9	6.4	3.3	3.3	5.7	4.1	0.3	0.3
6835H59M	RZM 5859%Maa x 835 (C)	140	0.0	0.0	0.0	2.0	2.3	4.7	3.0	0.0	0.0
6835H34	RZM 5834mmaa x 835 (C)	129	0.0	1.0	3.0	2.7	3.0	5.3	3.7	1.0	1.0
6835H93M	RZM 5893Maa x 835 (C)	126	3.0	8.4	10.3	4.7	4.3	6.7	5.2	0.7	0.7
6835H95M	RZM 5895Maa x 835 (C)	128	0.0	1.9	6.8	3.3	3.3	6.0	4.2	1.0	1.0
5867 (T-O)	T-O sel. 4867-3, ..., -13	123	0.0	1.0	1.0	2.3	2.0	4.7	3.0	1.7	1.7
5867NB	Inc. 3867-3, -4, -5, -7, -8	129	5.0	9.0	12.0	2.3	1.7	5.0	3.0	1.7	1.7
5869	3867-# (C) mmaa x 3890-# (C) A	122	0.9	0.9	1.9	2.0	2.0	4.3	2.8	0.0	0.0
6869m (Iso)	RZM 5869mm	123	0.0	1.9	4.1	1.7	2.3	5.3	3.1	1.3	1.3
6869A	Inc. 5869mmaA	138	4.6	5.7	6.2	3.0	2.7	5.3	3.7	0.7	0.7
6869	5859mmaa x A	131	5.0	7.0	6.1	2.0	2.3	5.3	3.2	1.0	1.0
6869HO	5869HO x 5869	132	4.3	6.5	7.3	2.7	2.3	6.0	3.7	0.0	0.0
6869H10	5810mmaa x 5869	119	0.0	2.2	5.6	2.0	2.0	5.0	3.0	0.0	0.0

(cont.)

Variety	Description	Beets/ 100'	% Bolting					Powdery Mildew			Downey Mildew %infect
			No.	07/02	08/13	09/17	07/08	07/15	07/25	Mean	
6869H10M	5810Maa x 5869	112	0.0	3.5	4.4	2.3	1.7	4.7	2.9	0.0	
	5911-4mmaa x 5869	122	0.0	1.0	2.1	1.3	1.0	3.7	2.0	1.0	
	5911-4Maa x 5869	124	1.0	1.9	1.9	2.3	1.3	4.3	2.7	0.0	
	5915aa x 5869	106	2.3	3.5	3.5	1.0	2.0	4.7	2.6	0.2	
6869H25	5925aa x 5869	117	1.0	1.0	1.0	2.7	2.3	5.3	3.4	0.3	
	0790mmaa x 808 (C)	133	0.0	0.0	0.9	2.3	1.7	5.0	3.0	0.3	
	0790HO x 808 (C)	137	0.0	0.0	3.7	2.0	1.7	5.0	2.9	0.0	
	5810mmA	123	0.0	2.2	5.5	1.7	2.7	5.3	3.2	0.7	
6809	5810mmaa x 808 (C)	129	0.0	0.0	1.0	2.3	1.7	4.7	2.9	0.0	
	3890-# (C)mmaa x A	121	1.1	1.1	1.1	2.0	2.3	5.0	3.1	1.7	
	3867HO x 3890-# (C)A	141	0.0	0.0	0.0	3.0	2.0	4.7	3.2	0.3	
	RZM 5890, C890-1 (Rz)	123	0.0	0.0	2.4	1.7	2.0	4.7	2.8	0.7	
5810	0790mmaa x 4265-4279 (C1&C2)	129	0.0	0.0	0.0	1.7	2.0	5.0	2.9	0.0	
	0790HO x 4265-4279 (C1&C2)	124	0.0	0.0	0.0	1.7	2.7	5.3	3.2	0.7	
	4265-4279mmaa x A	123	0.0	0.0	0.0	3.0	1.7	4.3	3.0	0.3	
	5810Maa x 808 (C)	106	0.0	0.0	2.2	3.0	3.0	5.3	3.8	0.3	
6812M	RZM 5812M, C890-2/3 (WB41/42)	127	0.0	0.0	0.0	2.7	2.0	4.7	3.1	0.7	
	RZM 5814M, C890-4 (PI07)	123	0.0	0.0	0.0	3.0	2.3	5.0	3.4	1.7	
	RZM 5815M, C890-5 (R04)	135	0.0	0.0	0.0	1.7	1.3	4.7	2.6	0.7	
	RZM 5815mm, C890-5 (R04)	123	0.0	0.0	0.0	0.7	1.7	4.7	2.3	0.0	
6816M	RZM 5277M, C890-6 (R05)	133	0.0	0.0	0.0	1.7	2.3	5.0	3.0	0.3	
	RZM 5268M, C890-7 (SES)	129	0.0	0.0	0.0	2.7	2.7	5.0	3.4	1.0	
	RZM 5270, 2M, C890-8 (R22)	132	0.0	0.0	0.0	2.7	2.3	5.3	3.4	0.0	
	RZM 5270, 2mm, C890-8 (R22)	113	2.1	4.6	4.6	2.0	2.7	5.7	3.4	0.3	
6819M	RZM 5819M, C890-9 (WB151)	123	0.0	0.0	0.0	2.0	0.7	4.3	2.3	1.3	
	RZM 5278M, C890-10 (WB169)	121	0.0	0.0	0.0	1.7	1.3	4.7	2.6	3.0	
	RZM 5279M, C890-11 (WB258)	121	0.0	1.4	1.4	2.7	2.7	5.7	3.7	0.3	
	RZM 5828-3, -6, -12, -13mm	121	0.0	1.1	2.2	2.0	2.7	5.7	3.4	0.0	

TEST 297. NONBOLTING EVALUATION OF MONOGERM LINES & POPULATIONS, SALINAS, CA., 1996-97

(cont.)

Variety	Description	Beets/ 100'	% Bolting				Powdery Mildew			Downey Mildew %infect
			07/02	08/13	09/17	07/08	07/15	07/25	Mean	
		No.								
6831-4	RZM T-O sel. 4831-4mm⊗	128	0.0	0.0	0.0	0.3	1.0	4.0	1.8	0.0
6833m	RZM 5833-#'s (C)mm	131	3.0	5.2	6.0	3.3	3.7	6.0	4.3	1.3
6833%M	RZM-%S 4833%M	136	0.0	1.7	1.7	2.7	2.7	5.7	3.7	0.0
6833%M	RZM-%S 4833%M	118	4.3	7.6	14.3	2.3	2.7	5.3	3.4	1.3
6834%M	RZM-%S 4834%M	121	1.0	1.0	1.9	2.3	1.3	4.7	2.8	0.7
6834%M	RZM-%S 4834%M	131	0.0	1.9	2.8	3.0	1.3	5.7	3.3	0.7
6836M	RZM 5911-4-#, 5829-#, 5830-#, 5831-#M	136	0.0	0.0	3.5	2.7	2.7	5.0	3.4	0.7
6836m	RZM 5911-4-#, 5829-#, 5830-#, 5831-#mm	115	0.0	0.0	0.0	1.7	1.7	4.7	2.7	0.3
6837M	T-O sel. RZM 5911-4-#, 5829-#, 5830-#, 5831-#, 5832-#M	123	0.0	0.0	3.0	1.7	1.7	4.3	2.6	0.3
6837m	T-O sel. RZM 5911-4-#, 5829-#, 5830-#, 5831-#, 5832-#mm	101	6.4	12.3	12.3	2.3	2.7	6.0	3.7	0.0
6859-8m	Inc. 2859mA(Sp)-8	133	1.6	4.0	3.4	3.3	3.7	6.3	4.4	0.0
6891-10m	Inc. 2891mA(Sp)-10	123	0.0	0.0	1.1	1.7	1.0	5.0	2.6	3.0
Mean		122.9	0.86	1.79	2.71	2.33	2.25	5.10	3.23	0.65
LSD (.05)		31.3	2.91	4.22	5.23	1.16	1.41	1.03	0.91	1.67
C.V. (%)		15.7	208.75	145.89	120.46	30.66	38.82	12.55	17.44	159.12
F value		1.0NS	2.38**	3.02**	2.93**	3.22**	2.26**	3.20**	3.89**	1.45*

NOTES: See note for Test 197. 835(C)= code for composite of C562, C546, C718, C762-17 & C796-43 used as pollinator in crosses to Rz to combine mm, T-O, CTR with Rz.



TEST 797. NONBOLTING EVALUATION; SELECTION FOR COMBINED RESISTANCE TO  
BOLTING RHIZOMANIA, ERWINIA, POWDERY MILDEW, etc.; AND BORDERS,  
BLOCK 2N (East Side), SALINAS, CA., 1996-97

60 varieties x 1 rep.  
1-row plots, rows 624 ft. long

Planted: November 13, 1996  
Not harvested for yield

Variety	Description	Stand	% Bolting		
		Count			
		No.	07/02	08/13	09/17
<u>MM,S<sup>s</sup>S<sup>s</sup>,Rz Lines</u>					
R678 (Iso)	NB-RZM R478NB (C78)	746	0.1	0.1	0.3
R678/2	RZM R578/2 (C78/2)	372	0.0	0.5	0.5
R678 (Sp)	RZM R578 (Sp), R578 (Sp)	772	1.0	2.3	2.3
R680 (Iso)	RZM R580	372	0.0	0.0	0.0
R680NB	NB-RZM R480NB	721	0.1	0.4	0.6
R680-#	NB-RZM R480-#, -45 (C80)	622	0.5	1.0	1.0
R680 (Sp)	RZM R580, NB, %, -#, -45	747	1.3	3.5	5.0
R681	NB-RZM R482NB, R484, R481-43, R481-89 (C82)	750	0.3	0.8	2.3
Y668	RZM Y568	818	0.5	3.2	4.2
Y669	RZM Y569	824	1.6	3.9	4.9
Y662	RZM Y562R	387	1.0	7.0	7.8
Y663	RZM Y563R	381	3.1	10.5	12.3
<u>MM,S<sup>s</sup>S<sup>s</sup>,RZM Lines with Bvm gp</u>					
Y673	U86-37 x Y71 (C)	1426	0.8	2.2	2.2
Y671	RZM 5205, P; 6, P; 7, P; 8, P (13% Bm)	444	0.5	2.3	2.3
Y672	RZM 5280, P; 4, P (3% Bm)	452	0.4	1.1	1.1
Y671 (Sp)	RZM 5205, P; 6, P; 7, P; 8, P; Y566; Y567	784	4.6	6.9	7.3
Y666	RZM Y566 (13% Bm)	553	1.3	3.1	3.1
Y667	RZM Y567 (13% Bm)	490	2.4	2.4	5.9
Y664	RZM Y564R (25% Bm)	413	1.9	6.8	7.0
Y665	RZM Y565 (6% Bm)	424	6.4	8.7	10.8
R636	RZM R536 (13% Bm) (C79-8)	215	2.3	2.3	2.3
R646	RZM R546 (6% Bm)	178	0.6	0.6	0.6
R653	RZM R5243, P (3% Bm)	164	0.0	1.2	1.2
R643	RZM-%S R443 (13% Bm)	178	21.3	33.7	33.7
R645	RZM R543, R545 (R04) (C79-5)	211	6.6	6.6	6.6
R637	RZM R537, R550 (WB151) (C79-9)	215	2.3	1.4	1.4
R641	RZM R541, R548 (WB169) (C79-10)	223	1.8	3.1	3.1
R642	RZM R542, R549 (WB258) (C79-11)	232	5.2	10.8	10.8
R640	RZM R540% (Iso)	216	2.3	5.6	5.6
R640-1	RZM-%S R440-1, R540-1	191	2.1	2.6	5.2
R651	RZM R551	192	3.1	5.2	5.2
R635	RZM R535 (gh) (SES) (C79-7)	206	1.0	2.4	2.9

TEST 797. NONBOLTING EVALUATION; SELECTION FOR COMBINED RESISTANCE TO  
BOLTING RHIZOMANIA, ERWINIA, POWDERY MILDEW, etc.; AND BORDERS,  
BLOCK 2N (East Side), SALINAS, CA., 1996-97

(cont.)

Variety	Description	Stand	% Bolting		
		Count			
		No.	07/02	08/13	09/17
<u>MM, S<sup>f</sup>, Aa, Rz Popns</u>					
R609	CR-RZM R409 (CR09)	199	1.0	4.0	4.5
R609R2	CR-RZM R409R2	211	0.0	1.9	1.9
R610	CR-RZM R410 (CR10)	216	0.0	1.9	2.3
C610R2	CR-RZM R410R2	216	16.7	24.1	26.4
6931	5915, 5925aa x 931 (C)	1340	0.7	2.1	2.6
6925	YR 4909, 4911-4, 4915, 4918-# (C)	805	0.1	0.7	0.7
6929	RZM R581H11, R581H18, R576-89-18H18	750	1.6	2.3	2.7
6930	RZM R578H11, R578H16, ...	804	0.7	0.9	1.7
6913-70 (Sp)	5913-70aa x A (C913-70)	836	0.1	0.5	0.5
<u>MM, S<sup>f</sup>, Aa, RZM Popns with Bvm gp</u>					
6926	RZM 5287, P	447	0.0	0.4	0.4
6927	RZM 5921H18	441	4.3	7.3	7.3
6921H15	5915aa x RZM-%S R21 (C)	702	6.0	10.1	10.1
6921H25	5925aa x RZM-%S R21 (C)	805	5.0	7.1	7.1
6931H21	5921H18aa x 931 (C)	808	2.7	4.2	4.2
<u>mm, S<sup>f</sup>, Aa, Rz Popns</u>					
6869	5869mmaa x A	1915	2.5	5.5	7.2
6828m	RZM 5828-3, -6, -12, -13mm	393	0.0	0.0	0.0
6890 (Iso)	RZM 5890, C890-1 (Rz)	384	0.0	0.5	0.5
6833m	RZM 5833-#'s (C)mm	182	0.0	0.5	1.1
6834%mm	RZM-%S 4834%mm	206	0.0	0.5	1.0
6836m	RZM 5911-4-#, 5829-#, ...mm	200	0.0	0.5	1.5
6837m	T-O Sel. RZM 5911-4-#, ...mm	347	4.0	8.1	8.1
6869H11	5911mmaa x 5869	393	2.5	2.5	2.5
6835H11m	4911-4mmaa x 835 (C)	187	0.0	0.0	0.5
6835H69m	5869mmaa x 835 (C)	213	0.0	0.5	0.5
6835H67m	RZM 5867Nbmmaa x 835 (C)	218	0.0	3.7	4.6
6835H34m	RZM 3834mmaax 835 (C)	196	4.1	4.1	6.1
<u>mm, S<sup>f</sup>, Aa, RZM Popns with Bvm gp</u>					
6806	0790mmaa x 808 (C)	1658	0.7	0.7	0.8
6835H10m	5810mmaa x 835 (C)	207	1.4	0.5	0.5

NOTE: Had 1996-97 been a year with adequate bolting induction, these would have been candidate lines from which to make selections for nonbolting.

112 entries x 3 replications, systematic  
1-row plots, 26 ft. long

Planted: November 13, 1996  
Not harvested for yield

Variety	Description	Beets/ 100'	% Bolting				Powdery Mildew		Downey Mildew	
			07/02	08/13	09/17	07/08	07/25	Mean	%infect	%infect
US H11	L111102 (9-24-96)	136	1.0	1.0	1.0	2.3	6.3	4.3	0.3	0.3
WS-PM9	HM, L5M011661C, 4-18-95	144	14.4	15.3	16.2	3.7	6.3	5.0	0.7	0.7
SS-NB3	SS, L905-34, 1993	127	1.1	1.1	1.1	3.0	5.7	4.3	0.0	0.0
SS-781R	SS, L941000, 8-21-95	155	1.0	3.1	3.1	3.0	5.3	4.2	0.0	0.0
Rizor	SES, F291, 2-13-96	160	0.0	5.8	11.1	3.3	7.0	5.2	0.3	0.3
Rival	HH103, 8-29-95	153	22.3	35.9	37.7	3.7	6.7	5.2	4.0	4.0
4006R	BTS, 2-8-96	155	0.8	3.1	5.2	2.0	5.7	3.8	0.0	0.0
4454	BTS, 4002, 4-28-95	160	2.4	10.2	13.3	2.7	4.7	3.7	0.3	0.3
SS-NB2R2	SS, L93606, 8-28-95	151	0.9	4.2	6.8	3.7	6.0	4.8	0.0	0.0
SS-NB7R	SS, L950840, 11-13-95	153	7.2	9.1	10.0	3.0	5.7	4.3	1.0	1.0
SS-694R	SS, 11-13-95	158	5.5	7.2	8.1	2.7	5.3	4.0	0.0	0.0
R581H50	F92-790-15CMS x RZM R481-43, -89	153	5.8	9.2	10.9	1.7	4.0	2.8	0.3	0.3
R576-89-18H50	F92-790-15CMS x R476-89-18	141	1.7	1.7	1.7	0.7	4.7	2.7	0.0	0.0
5911-4H50	F92-790-15CMS x RZM 4911-4	127	0.0	1.1	1.1	1.3	4.7	3.0	0.0	0.0
R579H50	F92-790-15CMSxRZM R479,C79-1,Rz	113	6.6	11.1	13.4	2.3	5.7	4.0	0.7	0.7
R578H50	F92-790-15CMS x RZM R478NB	145	0.0	2.8	5.4	2.3	4.7	3.5	0.7	0.7
R678H50	F92-790-15CMS x R578 (Sp)	144	0.0	1.7	2.5	2.3	5.0	3.7	0.3	0.3
R680H50	F92-790-15CMS x R580,NB	145	0.8	0.8	0.8	1.3	4.7	3.0	0.0	0.0
Y671H50	F92-790-15CMS x Y71 (C)	149	1.7	2.5	2.5	2.0	4.7	3.3	0.0	0.0
6913-70H50	F92-790-15CMS x 5913-70 (C913-70)	160	0.0	0.0	0.0	1.7	5.0	3.3	0.3	0.3
6911-4-10H50	F92-790-15CMS x RZM 4911-4-10M	151	0.0	0.0	0.0	1.3	4.7	3.0	0.0	0.0
6915-7-6H50	F92-790-15CMS x RZM 4915-7-6	144	0.0	3.5	3.5	0.7	4.0	2.3	0.7	0.7
6918-3H50	F92-790-15CMS x RZM 4918-3	154	0.0	0.7	0.7	1.3	4.3	2.8	0.0	0.0
6918-12H50	F92-790-15CMS x RZM 4918-12	137	0.0	1.9	1.9	0.7	4.0	2.3	0.0	0.0
6918-21H50	F92-790-15CMS x RZM 4918-21	135	0.0	1.0	1.0	1.0	4.3	2.7	0.0	0.0

TEST 397. NONBOLTING EVALUATION OF EXPERIMENTAL HYBRIDS, SALINAS, CA., 1996-97

(cont.)

Variety	Description	Beets/ 100'	% Bolting				Powdery Mildew			Downey Mildew	
			No.	07/02	08/13	09/17	07/08	07/25	Mean	%	infect
6921H50	F92-790-15CMS x RZM-8S R21 (C)	154		4.3	8.6	8.6	1.3	5.0	3.2	0.0	0.0
6931H50	F92-790-15CMS x RZM 931 (C)	138		2.0	2.0	2.0	1.3	4.7	3.0	0.3	0.3
6931H70	5869HO x RZM 931 (C)	135		2.0	9.2	10.1	2.0	6.0	4.0	0.3	0.3
6931H88	5890HO x RZM 931 (C)	133		0.0	2.0	2.0	2.7	5.3	4.0	0.0	0.0
6931H21	5921H18aa x RZM 931 (C)	137		4.5	11.3	11.3	1.7	4.3	3.0	0.0	0.0
6869H11M	5911-4Maa x 5869	132		1.1	4.5	4.5	2.0	5.0	3.5	0.7	0.7
6869H15	5915aa x 5869	129		0.0	4.0	4.0	2.3	5.0	3.7	1.3	1.3
6869H25	5925aa x 5869	140		0.0	2.0	3.8	2.3	5.7	4.0	0.0	0.0
6835H18	RZM 4918aa x 835 (C)	138		0.0	2.4	2.4	2.7	5.7	4.2	0.0	0.0
6835H11M	RZM 4911-4Maa x 835 (C)	129		0.0	1.1	4.2	2.7	5.7	4.2	0.3	0.3
Y671H7	5911-4-7CMS x Y71 (C)	140		4.9	5.9	10.4	2.3	5.0	3.7	0.7	0.7
Y671H37	4807HO x Y71 (C)	153		0.8	4.2	4.2	2.7	5.7	4.2	0.3	0.3
Y671H15	5915aa x Y71 (C)	87		1.5	2.5	5.5	2.0	6.0	4.0	0.3	0.3
Y671H25	5925aa x Y71 (C)	124		3.1	3.1	3.1	1.7	5.0	3.3	0.7	0.7
6913-70H52	F92-790-15H39 x 5913-70	149		1.0	1.8	2.6	1.3	4.0	2.7	0.0	0.0
6913-70H37	4807HO x 5913-70	140		0.0	0.0	0.0	1.0	4.3	2.7	0.0	0.0
6913-70H39	91-762-17CMS x 5913-70	122		0.0	0.0	0.0	1.3	4.3	2.8	0.0	0.0
6913-70H70	6869HO x 5913-70	145		1.8	7.1	7.1	2.0	5.3	3.7	0.0	0.0
R678H50	F92-790-15CMS x R578 (sp)	126		0.0	1.1	1.1	2.3	5.3	3.8	0.0	0.0
R678H50NB	5790-15CMS x R578 (sp)	132		1.0	6.0	9.0	2.3	4.7	3.5	0.0	0.0
F678H50-21	5790-15-21CMS x R578 (sp)	132		0.0	3.8	3.8	1.7	5.3	3.5	0.7	0.7
R678H50-23	5790-15-23CMS x R578 (sp)	146		0.0	3.6	4.5	2.0	5.3	3.7	0.3	0.3
R678H39	91-762-17CMS x R578 (sp)	138		1.7	3.6	3.6	2.7	5.7	4.2	0.7	0.7
R678H72	U83-718HO x R578 (sp)	135		2.0	5.6	5.6	2.3	6.0	4.2	0.7	0.7

(cont.)

Variety	Description	Beets/ 100'	% Bolting				Powdery Mildew			Downey Mildew	
			No.	07/02	08/13	09/17	07/08	07/25	Mean	%infect	
R678H7	5911-4-7CMS x R578 (Sp)	153	5.2	6.8	7.7	2.3	5.0	3.7	0.0		
	5869HO x R578 (Sp)	159	16.1	25.8	26.6	3.0	6.0	4.5	0.7		
	5867HO x R578 (Sp)	140	7.5	11.9	11.9	3.0	6.0	4.5	1.7		
	5867NBHO x R578 (Sp)	150	13.8	16.5	17.3	2.3	5.3	3.8	0.3		
R678H87	5890aa x R578 (Sp)	145	2.8	4.5	5.4	3.0	5.7	4.3	0.3		
	5810aa x R578 (Sp)	144	1.0	1.0	1.0	2.0	5.7	3.8	0.3		
	5810HO x R578 (Sp)	131	0.0	2.0	2.0	1.7	5.7	3.7	0.7		
	5890HO x R578 (Sp)	145	0.0	2.6	2.6	2.3	5.3	3.8	0.3		
R678H34	5834aa x R578 (Sp)	137	1.9	3.7	3.7	2.7	6.3	4.5	0.3		
	5859%aa x R578 (Sp)	123	1.1	2.2	2.2	3.3	6.3	4.8	0.7		
	5895aa x R578 (Sp)	144	4.5	8.0	8.0	3.3	6.3	4.8	1.3		
	Z325aa x R578 (Sp)	138	4.7	8.2	10.1	2.7	5.7	4.2	2.0		
R678H11M	5911-4Maa x R578 (Sp)	135	0.9	0.9	0.9	2.3	5.7	4.0	0.3		
	L111102 (11-16-94)	138	0.0	0.0	0.9	3.0	6.7	4.8	0.3		
	SS,L941000,3-95	131	1.2	4.7	6.0	3.0	5.3	4.2	0.7		
	2867mA (Sp) - 1aa x R578 (Sp)	138	1.0	5.7	5.7	3.0	5.3	4.2	2.7		
R678H59-8	2859mA (Sp) - 8aa x R578 (Sp)	122	3.4	5.4	5.4	3.3	6.0	4.7	0.7		
	2891mA (Sp) -10aa x R578 (Sp)	132	1.8	5.7	5.7	3.0	6.0	4.5	0.3		
	5833-1aa x R578 (Sp)	131	1.9	1.9	3.8	1.3	5.3	3.3	1.0		
	5833-2aa x R578 (Sp)	122	4.0	10.0	10.0	3.7	6.7	5.2	1.0		
R678H33-4	5833-4aa x R578 (Sp)	106	5.7	13.6	14.9	2.3	5.3	3.8	1.0		
	5833-5aa x R578 (Sp)	138	0.0	1.8	2.8	1.7	5.0	3.3	0.3		
	5933-6aa x R578 (Sp)	146	2.6	4.4	4.4	3.0	6.3	4.7	1.0		
	5833-8aa x R578 (Sp)	109	1.1	1.1	2.3	2.7	5.0	3.8	0.7		
R678H33-12	5833-12aa x R578 (Sp)	128	5.0	5.0	7.0	2.3	5.7	4.0	0.7		

TEST 397. NONBOLTING EVALUATION OF EXPERIMENTAL HYBRIDS, SALINAS, CA., 1996-97

(cont.)

Variety	Description	Beets/ 100'	% Bolting				Powdery Mildew		Downey Mildew %infect
			No.	07/02	08/13	09/17	07/08	07/25	
				Mean	Mean				
R678H33-13	5833-13aa x R578 (Sp)	122	0.9	4.2	4.2	3.3	6.7	5.0	1.7
R678H33-14	5833-14aa x R578 (Sp)	122	1.0	2.0	2.0	2.7	5.3	4.0	1.7
R678H33-15	5833-15aa x R578 (Sp)	103	15.6	29.5	39.9	3.3	5.7	4.5	0.0
R678H33-17	5833-17aa x R578 (Sp)	142	2.8	3.7	3.7	3.3	5.7	4.5	0.7
R678H33-19	5833-19aa x R578 (Sp)	85	2.8	12.5	15.7	3.7	6.7	5.2	1.0
R680H50	F92-790-15CMS x RZM R580,NB	122	1.1	1.1	2.2	2.3	5.0	3.7	0.3
R680H7	5911-4-7CMS x RZM R580,NB	147	7.2	7.2	7.2	1.0	4.0	2.5	0.7
R680H70	5869HO x RZM R580,NB	146	6.3	11.2	12.9	2.7	4.7	3.7	0.3
R680H88	5890HO x RZM R580,NB	144	2.0	7.7	7.7	2.0	4.7	3.3	0.0
US H11	11-16-94	128	0.0	1.0	1.0	2.7	6.3	4.5	0.3
R680H11-3	5911-4-3aa x RZM R580,NB	122	0.0	0.0	0.0	3.3	5.3	4.3	0.0
R680H11-5	5911-4-5aa x RZM R580,NB	82	10.8	10.8	12.2	0.7	4.0	2.3	2.0
R680H29-2	5829-2aa x RZM R580,NB	132	3.0	4.0	4.0	3.3	6.3	4.8	0.0
R680H29-3	5829-3aa x RZM R580,NB	132	0.9	1.9	1.9	3.0	5.7	4.3	0.0
R680H29-4	5829-4aa x RZM R580,NB	138	1.0	2.9	2.9	3.3	7.0	5.2	0.7
R680H29-5	5829-5aa x RZM R580,NB	113	1.0	4.0	4.0	3.3	5.7	4.5	0.0
R680H27-7	5829-7aa x RZM R580,NB	122	0.0	2.0	2.9	3.3	7.0	5.2	0.7
R680H30-1	5830-1aa x RZM R580,NB	140	1.0	2.1	2.1	2.7	5.0	3.8	1.0
R680H30-2	5830-2aa x RZM R580,NB	144	1.9	1.9	2.7	2.3	5.3	3.8	0.0
R680H30-3	5830-3aa x RZM R580,NB	119	0.0	1.1	1.1	3.0	6.3	4.7	0.0
R680H31-2	5831-2aa x RZM R580,NB	104	8.0	16.9	22.1	2.0	5.7	3.8	0.0
R680H31-3	5831-3aa x RZM R580,NB	149	2.0	2.7	2.7	2.0	5.0	3.5	0.0
R680H31-4	5831-4aa x RZM R580,NB	140	2.2	5.0	5.0	1.3	5.0	3.2	1.3
R680H31-5	5831-5aa x RZM R580,NB	141	0.0	0.9	2.5	2.0	5.7	3.8	0.0

(cont.)

Variety	Description	Beets/ 100'	% Bolting				Powdery Mildew		Downey Mildew %infect
			No.	07/02	08/13	09/17	07/08	07/25	
R680H31-6	5831-6aa x RZM R580,NB	129		0.0	1.0	1.9	2.0	5.3	3.7
R680H31-7	5831-7aa x RZM R580,NB	133		0.9	2.8	2.8	2.3	5.7	4.0
R680H31-8	5831-8aa x RZM R580,NB	96		3.2	5.8	5.8	2.3	5.0	3.7
R680H31-9	5831-9aa x RZM R580,NB	146		0.9	4.4	5.3	2.3	5.7	4.0
R680H31-10	5831-10aa x RZM R580,NB	137		0.9	1.9	1.9	2.3	4.3	3.3
R680H31-11	5831-11aa x RZM R580,NB	129		0.9	2.7	3.6	2.7	5.0	3.8
R680H32-1	5832-1aa x RZM R580,NB	108		6.2	12.1	15.0	2.7	5.7	4.2
R680H32-2	5832-2aa x RZM R580,NB	137		3.6	6.5	6.5	1.7	5.7	3.7
R680H32-3	5822-3aa x RZM R580,NB	118		1.0	10.0	10.0	2.7	5.0	3.8
R680H32-5	5832-5aa x RZM R580,NB	123		6.3	14.6	14.6	2.7	6.0	4.3
R680H32-7	5832-7aa x RZM R580,NB	136		1.0	3.9	4.8	3.0	6.3	4.7
6921H15	5915aa x RZM-%s R21(C)	137		11.3	15.1	15.1	2.7	5.3	4.0
6921H25	5925aa x RZM-%s R21(C)	115		2.2	5.5	6.7	2.0	5.0	3.5
R680H37	4807HO x RZM R580,NB	137		0.0	3.6	5.5	3.0	5.0	4.0
Mean		134.7		2.70	5.44	6.28	2.37	5.41	3.89
LSD (.05)		25.9		4.97	8.00	8.48	1.40	0.96	0.89
C.V. (%)		12.0		114.52	91.49	83.99	36.71	10.97	14.16
F value		2.8**		4.70**	4.11**	4.71**	2.18**	4.38**	4.60**

NOTES: See test note for Test 197. 5833-#'s, 5911-4-#'s, 5829-#'s, 5830-#'s, 5831-#'s, 5832-#'s are monogerm,Rz,S<sub>1</sub> lines topcrossed to a pollinator.

TEST 1397. ERWINIA/POWDERY MILDEW EVALUATION OF LINES, SALINAS, CA., 1997

160 entries x 3 replications, sequential  
1-row plots, 17 ft. long

Planted: March 4, 1997  
Scored: October 14-17, 1997  
Ecb Inoc.: July 11, 1997

Variety	Description	Powdery Mildew			Harvest		Stand		Erwinia		
		07/11	07/17	07/28	Mean	Count	Mean	Count	Rating	%R	
MM,O.P.											
Block 1											
US H11	L111102 (9-24-96)	2.0	3.0	6.7	3.9	21	21	8.5	58.5		
C40	BTS Inc. C40(Erwinia susc.ck.)	3.3	4.3	7.7	5.1	19	19	80.9	15.6		
U86-46/2	Inc. C46/2, 86342	1.0	1.3	5.3	2.6	22	21	8.1	75.4		
R678 (Iso)	NB-RZM R478NB (C78)	2.0	2.3	5.7	3.3	24	24	14.2	78.2		
R578/2	NB-ER-RZM R378,Y (C78/2)	1.3	2.3	5.7	3.1	21	21	3.3	93.3		
R678/2	RZM R578/2	1.0	2.0	5.7	2.9	21	21	7.6	84.8		
R578%	RZM-%S R378 (Sp)	1.7	2.3	6.0	3.3	22	22	13.6	78.5		
R539	NB-ER-RZM R139C7	1.3	2.7	5.0	3.0	19	19	11.3	78.8		
R639	RZM R539 (C39R)	1.3	2.3	5.3	3.0	19	18	4.0	84.6		
R547	NB-ER-RZM R147C7	1.7	3.0	5.7	3.4	21	20	1.2	98.4		
R647	RZM R547 (C47R)	1.3	2.0	5.3	2.9	21	22	3.0	95.4		
R680NB (Iso)	NB-RZM R480NB (C80NB)	1.7	3.0	6.3	3.7	21	20	16.6	71.8		
R580	NB-ER-RZM R380,Y	1.3	1.7	5.3	2.8	21	21	12.3	77.4		
R680 (Iso)	RZM R580	1.3	2.7	6.0	3.3	21	21	10.4	76.4		
R580%	RZM-%S R380 (Sp)	2.3	3.0	6.0	3.8	21	21	16.6	68.1		
R580-#	RZM R480-# (C80)	2.0	3.0	6.0	3.7	22	21	3.6	77.1		
Block 2											
R580-45	RZM R480-45 (C80-45)	1.7	3.3	6.0	3.7	21	20	5.6	89.4		
R680-#	NB-RZM R480-45,-# (C80)	1.0	2.7	5.0	2.9	19	19	3.0	86.0		
F86-31/6	Inc. C31/6, I86263	1.0	1.7	5.3	2.7	17	18	8.8	83.0		
R482NB	NB R276-43,-89 (C82)	0.7	2.0	5.3	2.7	21	21	23.9	64.1		
R576	NB-ER-RZM R376,Y	1.7	2.3	6.3	3.4	19	20	8.6	86.5		
R581 (Sp)	RZM R481-43,-89(C82)	1.3	1.7	5.7	2.9	20	19	7.4	86.3		
R681	NB-RZM R481-43,-89;...	2.0	2.7	5.7	3.4	21	22	11.5	80.9		
R576-89-18NB	NB-ER-RZM R376-89-18 (C76-89-18)	1.7	2.3	5.0	3.0	19	19	4.5	84.2		



(cont.)

Variety	Description	Powdery Mildew			Harvest Count	Stand Count	Erwinia	
		07/11	07/17	07/28	Mean	Mean	DI	Rating
MM,O.P. (cont.)								
Block 2 (cont.)								
R576-89-5NB	NB=ER-RZM R376-89-5 (C76-89-5)	2.0	2.3	5.3	3.2	20	3.5	91.5
Y662	RZM Y562R (Yrr x Rz)	1.3	2.3	6.0	3.2	20	15.8	68.3
Y663	RZM Y563R, (YR x Rz)	1.3	1.7	6.3	3.1	21	13.3	70.2
US H11	L111102 (9-24-96)	2.7	3.7	7.3	4.6	22	7.5	78.6
C40	Inc. C40 BTS	3.3	4.7	8.0	5.3	19	85.3	11.9
Y668	RZM Y568, F <sub>2</sub> (Yrr x Y62,Y63)	2.0	2.3	6.0	3.4	19	15.0	63.7
Y669	RZM Y569, F <sub>2</sub> (Yrr x Y62,Y63)	1.0	1.3	5.0	2.4	23	14.5	76.0
Y522Y4	RZM-%S R322Y3,%	2.0	2.0	5.0	3.0	19	26.1	58.8
Block 3								
R522(sp)	RZM R422R4,R322Y3;...(C51)	3.0	3.7	7.3	4.7	21	18.1	76.3
R626	RZM R526,F <sub>3</sub> (C37 x UK Bvm)	3.0	3.7	7.7	4.8	21	13.1	80.3
Y664	RZM Y564R, BC <sub>1</sub> F <sub>3</sub> (C78,...,C80 x R22)	2.0	2.3	6.0	3.4	22	22.6	67.1
Y665	RZM Y565, BC <sub>3</sub> F <sub>3</sub> (C80,C82 x R22)	2.3	3.3	6.3	4.0	23	9.3	83.0
Y666	RZM Y566, BC <sub>2</sub> F <sub>2</sub> (Yrr x Y64)	1.3	2.3	5.7	3.1	22	13.5	80.6
Y667	RZM Y567, BC <sub>2</sub> F <sub>2</sub> (Yrr x Y64)	0.7	2.0	5.3	2.7	22	10.3	79.5
Y671	RZM 5205,P;...,BC <sub>2</sub> F <sub>2</sub> (C78,...,C80 x R22Y)	2.3	3.0	6.7	4.0	22	14.4	78.2
Y671(sp)	RZM 5205,P,...	1.3	2.3	5.0	2.9	21	12.4	72.4
Y672	RZM 5280,P;5284,P,BC <sub>3</sub> F <sub>2</sub> (C80 x R22)	1.3	2.7	6.7	3.6	22	11.0	84.4
Y671H15	5915aa x Y71(C)	1.7	2.3	6.0	3.3	22	8.4	74.4
Y671H25	5925aa x Y71(C)	1.7	2.3	6.0	3.3	20	5.6	80.6
R640	RZM R540%(Iso),BC <sub>n</sub> F <sub>2</sub> (C37 x C79-#s)	3.0	4.3	7.3	4.9	22	20.1	67.9
R640-1	RZM-%S R440-1,BC <sub>n</sub> F <sub>2</sub> (C37 x C79-#s)	2.7	4.3	7.3	4.8	21	14.3	69.5
R651	RZM R551,BC <sub>n</sub> F <sub>2</sub> (C37 x C79-#s)	3.0	4.3	7.0	4.8	21	9.0	81.2
US H11	L113401	1.3	3.3	6.0	3.6	23	4.7	79.0
E840	Inc. C40 BTS	3.7	3.7	7.7	5.0	19	79.4	11.7

TEST 1397. ERWINIA/POWDERY MILDEW EVALUATION OF LINES, SALINAS, CA., 1997

(cont.)

Variety	Description	Powdery Mildew			Harvest		Stand		Erwinia		
		07/11	07/17	07/28	Mean	Count	Mean	Count	DI	%R	
MM,O.P. (cont.)											
Block 4											
R643	RZM-%S R443,BC <sub>2</sub> F <sub>3</sub> [C82 x (C37 x R22)]	4.3	3.0	7.3	4.9	20	19	51.9	38.2		
U86-37	Inc. C37, L86443	3.0	4.0	7.7	4.9	16	16	8.9	65.1		
R679	RZM R579 (C37Rz, C79-1)	2.3	2.7	6.3	3.8	20	21	11.2	73.5		
R635	RZM R535 (SES) (C79-7)	3.3	3.7	6.7	4.6	21	20	11.6	71.7		
R637	RZM R537, R550 (WB151) (C79-9)	1.0	3.0	6.3	3.4	20	21	14.8	61.1		
R641	RZM R541, R548 (WB169) (C79-10)	2.3	3.3	6.7	4.1	20	19	7.1	75.5		
R642	RZM R542, R549 (WB258) (C79-11)	2.3	3.0	6.0	3.8	19	19	19.9	51.9		
R645	RZM R545, R542 (R04) (C79-5)	3.3	5.0	6.7	5.0	20	20	20.0	55.4		
R636	RZM R536 (R22) (12%) (C79-8)	4.0	4.3	8.0	5.4	18	20	36.4	47.3		
R646	RZM R546,BC <sub>3</sub> F <sub>3</sub> (C37 x R22) (6%)	2.7	3.7	7.3	4.6	21	21	30.9	42.9		
R653	RZM 5243,P,BC <sub>4</sub> F <sub>2</sub> (C37 x R22) (3%)	1.7	3.3	6.7	3.9	18	17	8.9	62.7		
MM,S <sup>f</sup> ,Aa Populations											
R609	CR-RZM R409, (CR09)	1.3	1.7	5.3	2.8	17	18	15.7	70.6		
R609R2	CR-RZM R409R2	2.0	3.0	6.3	3.8	18	17	17.1	61.9		
R610	CR-RZM R410, (CR10)	0.7	2.0	6.3	3.0	19	19	13.3	71.4		
R610R2	CR-RZM R410R2	2.0	2.7	7.0	3.9	19	18	15.1	69.0		
N621	NR-RZM N521,N522	1.7	2.7	6.0	3.4	18	17	10.4	70.7		
Block 5											
N627	NR-RZM N527,N528	3.0	2.7	6.0	3.9	16	18	6.8	87.6		
US H11	L113401	3.3	4.0	6.7	4.7	19	19	7.7	71.2		
E840	Inc. C40 BTS	3.0	4.7	7.3	5.0	19	21	80.6	13.8		
NN661	NR-RZM N561,...,N564	1.7	3.7	6.7	4.0	21	21	18.5	72.8		
P601	PMR P401, PMR from WB97	0.3	2.0	5.0	2.4	20	19	6.9	76.2		
P602NR	NR P202, PMR from WB242	1.0	2.3	4.7	2.7	20	20	9.0	74.1		
P603	PMR P403, PMR from WB97,242	1.0	2.3	4.7	2.7	22	21	7.8	84.4		
P604	PMR P404, PMR from WB97,242	1.0	1.7	4.3	2.3	21	21	10.2	70.8		

(cont.)

Variety	Description	Powdery Mildew			Harvest		Stand		Erwinia		
		07/11	07/17	07/28	Mean	Count	Mean	Count	DI	Rating	
MM,S <sup>f</sup> ,Aa Populations (cont.)											
Block 5 (cont.)											
4918	RZM 3918aa x A (C918)	1.3	2.3	6.3	3.3	21	20		8.6	81.3	
5915 (sp)	RZM 4911,4915,4918aa x A	1.3	2.3	5.7	3.1	21	21		5.4	81.0	
6915	NB-RZM 4911,M	1.0	1.7	5.3	2.7	20	20		9.7	70.9	
5925	S <sub>1</sub> (MM,A:aa,Rz) (C)aa x A	1.0	2.3	5.7	3.0	20	20		10.5	70.5	
6925	YR-%S (Davis) 4909...# (C)	2.0	3.0	6.7	3.9	21	22		5.6	80.2	
6931	5915aa,...,aa x A (S <sub>1</sub> )	1.7	2.0	5.7	3.1	20	21		9.4	69.8	
6924	RZM 5924, F <sub>2</sub> (918aa x Y#)	1.7	2.0	5.3	3.0	19	20		5.5	71.7	
6929	RZM R581H11,H18,...	2.3	3.3	6.0	3.9	21	22		10.2	77.8	
Block 6											
6930	RZM R578H11,H16,...	2.0	2.3	5.3	3.2	19	19		11.2	66.5	
6931H21	5921H18 x 931 (C)	1.3	1.0	6.0	2.8	21	21		10.1	80.4	
6920	RZM 5920,BC <sub>3</sub> F <sub>3</sub> (918aa x R22)	2.0	2.3	6.3	3.6	18	18		18.6	67.4	
6921	RZM R522H18 (25% R22)	1.7	2.3	6.7	3.6	19	19		17.6	67.4	
6921 (sp)	RZM-%S R21 (C) , BC <sub>1</sub> F <sub>2</sub> (918aa x R22)	2.3	3.7	6.7	4.2	21	20		17.0	71.8	
6921H15	5921aa x RZM-%S R21 (C) (12% R22)	1.7	2.7	6.0	3.4	20	20		15.0	70.4	
6921H25	5925aa x RZM-%S R21 (C) (12% R22)	1.7	3.7	6.0	3.8	20	20		15.7	60.0	
6926	RZM 5287,P,BC <sub>4</sub> F <sub>2</sub> (918aa x R22)	1.7	1.3	5.7	2.9	20	20		18.4	67.1	
6927	RZM 5921H18, BC <sub>2</sub> F <sub>2</sub> (918aa x R22)	1.3	2.3	6.0	3.2	21	21		9.9	75.6	
6922	RZM 5922, BC <sub>1</sub> F <sub>3</sub> (918aa x C79-#s)	1.3	2.7	6.0	3.3	19	18		10.4	67.0	
US H11	L113401	2.3	3.7	7.3	4.4	21	21		5.5	71.3	
E840	Inc. C40 BTS	3.7	4.7	7.7	5.3	18	18		87.5	7.8	
6923	RZM 5923, BC <sub>1</sub> F <sub>2</sub> (918aa x C79-#s)	1.3	2.0	6.0	3.1	18	18		13.7	62.7	
6913-70 (Iso)	RZM 5913-70, (C913-70)	1.0	1.3	5.7	2.7	19	19		2.0	91.5	
6913-70 (Sp)	RZM 5913-70aa x A, (C913-70)	1.0	2.0	6.0	3.0	20	21		0.1	98.3	
6913-70A (Sp)	RZM 5913-70A (C913-70)	1.7	2.3	6.0	3.3	20	21		3.2	86.1	

TEST 1397. ERWINIA/POWDERY MILDEW EVALUATION OF LINES, SALINAS, CA., 1997

(cont.)

Variety	Description	Powdery Mildew			Harvest		Stand		Erwinia		
		07/11 07/17 07/28			Count		Count		Rating		
		Mean	Mean	Mean	Mean	Mean	Mean	DI	%R		
MM,S <sup>f</sup> ,Aa Populations (cont.)											
Block 7											
6911-4-7	RZM 5911-4-7	1.0	2.3	5.3	2.9	20	20	4.5	76.9		
6911-4-10	RZM 5911-4-10	0.3	1.0	4.3	1.9	21	21	9.2	69.0		
6915-7-6	RZM 4915-7-6	0.3	0.3	4.7	1.8	19	20	6.8	74.9		
6918-3	RZM 4918-3	1.0	2.0	5.3	2.8	20	20	4.2	86.5		
6918-12	RZM 4918-12	0.3	1.0	5.0	2.1	21	21	3.1	89.1		
5911-4 (Iso)	NB-ER-RZM 3911-4 (C911-4)	1.3	2.0	6.0	3.1	21	22	8.3	76.1		
US H11	L113401	3.3	4.0	7.7	5.0	23	23	10.6	67.3		
E840	Inc. C40 BTS	3.3	4.7	7.3	5.1	20	21	86.1	8.2		
6262A(C)	5262A $\otimes$ , BC <sub>1</sub> F <sub>3</sub> (918aa x CTR)	2.7	3.3	6.7	4.2	20	20	17.1	63.9		
6263A(C)	5263A $\otimes$ , F <sub>2</sub> (918aa x CTR)	2.7	3.0	7.3	4.3	20	21	22.8	66.5		
6264(C)	4918aa x 5264CMSPF,BC <sub>1</sub> F <sub>3</sub> (918aa x Root aphid resistance)	1.3	2.3	6.0	3.2	18	19	12.4	67.3		
mm,S <sup>f</sup> ,Aa Populations and Lines											
6562	Inc. F82-562 (*)	3.3	4.3	7.7	5.1	20	20	31.0	51.1		
6546	Inc. F82-546 (*)	3.0	3.7	7.0	4.6	18	19	17.8	63.0		
6718	Inc. U83-718 (*)	2.3	2.7	6.7	3.9	16	17	34.8	35.3		
6762-17	Inc. 0762-17,2762-17 (*)	1.3	1.3	6.0	2.9	21	20	56.7	26.8		
6796-43	Inc. 0796-43 (*)	3.7	5.0	7.3	5.3	18	19	25.8	45.3		
(*) composite = 835(C). Inc. w/o separate isolation											
Block 8											
6835H18	RZM 4918aa x 835(C)	2.7	3.7	6.7	4.3	19	19	14.6	56.7		
6835H11	4911-4mmaa x 835(C)	2.3	2.7	6.0	3.7	19	20	11.5	55.2		
US H11	L113401	3.0	4.3	7.3	4.9	23	24	7.1	71.4		
E840	Inc. C40 BTS	4.0	5.3	8.0	5.8	21	21	88.3	7.5		
6835H10	5810mmaa x 835(C)	2.0	3.0	6.7	3.9	21	20	12.8	54.7		
6835H69	5869mmaa x 835(C)	2.0	3.0	6.3	3.8	23	23	15.8	62.8		
6835H67	RZM 5867NBmmaa x 835(C)	2.7	3.3	7.0	4.3	21	22	23.4	48.5		
6835H34	RZM 5834mmaa x 835(C)	3.0	3.3	6.0	4.1	19	21	30.1	41.1		

(cont.)

Variety	Description	Powdery Mildew				Harvest		Stand		Erwinia	
		07/11		07/28		Count		Count		Rating	
		Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	DI	%R
mm,S',Aa Populations and Lines (cont.)											
Block 8 (cont.)											
6835H93M	RZM 5893Maa x 835(C)	3.7	4.0	8.0	5.2	21	20	11.6	65.6		
6835H95M	RZM 5895Maa x 835(C)	3.0	3.7	7.3	4.7	23	22	14.0	63.1		
5869	3867-#(C)maa x 3890-#(C)A	2.0	2.7	6.3	3.7	21	20	22.9	44.4		
6869m(Iso)	RZM 5869mm	2.7	3.7	6.7	4.3	23	23	18.9	65.8		
6869	5859mmaa x A	2.3	3.7	7.3	4.4	24	23	5.0	83.3		
6869HO	5869HO x 5869	2.3	3.7	6.7	4.2	22	22	9.5	74.3		
6869H10	5810mmaa x 5869	1.7	2.7	6.3	3.6	20	21	9.2	68.9		
6869H11	5911-4mmaa x 5869	2.0	3.0	6.0	3.7	21	22	16.4	56.4		
Block 9											
6869H15	5915aa x 5869	1.3	3.0	6.0	3.4	22	22	5.3	85.6		
6869H25	5925aa x 5869	1.7	3.3	6.7	3.9	22	21	13.1	72.3		
6808	0790mmaa x 808(C)	2.0	3.0	6.7	3.9	21	22	22.4	41.3		
6808HO	0790HO x 808(C)	2.3	3.3	6.7	4.1	22	22	20.2	52.4		
6809	5810mmaa x 808(C)	2.3	4.3	7.3	4.7	21	22	18.5	57.9		
6890(Iso)	RZM 5890,C890-1(Rz)	2.7	3.3	6.3	4.1	22	22	17.4	63.0		
5810	0790mmaa x 4265-4279 (C1 & C2)	2.0	3.3	6.3	3.9	21	22	23.6	48.6		
4890m	RZM 3890mmaa x A (C890)	2.0	3.0	7.0	4.0	19	20	15.3	51.2		
E840	Inc. C40 BTS	3.3	4.3	8.0	5.2	19	20	82.9	13.6		
6812M	RZM 5812M, C890-2/3 (WB41/42)	2.0	3.7	6.7	4.1	20	20	22.1	49.1		
6814M	RZM 5814M, C890-4 (PI07)	2.3	4.3	7.3	4.7	20	20	19.1	60.0		
6815M	RZM 5815M, C890-5 (R04)	2.3	3.7	7.3	4.4	21	20	17.2	56.3		
6816M	RZM 5277M, C890-6 (R05)	1.3	2.3	6.0	3.2	19	20	17.4	51.7		
6817M	RZM 5268M, C890-7 (SES)	3.0	3.7	6.7	4.4	19	19	34.3	43.1		
6818M	RZM 5270,2M,C890-8 (R22)	2.3	3.7	6.3	4.1	20	20	34.3	41.7		
6818m	RZM 5270,2mm,C890-8 (R22)	2.0	2.3	5.7	3.3	18	18	35.9	35.2		

TEST 1397. ERWINIA/POWDERY MILDEW EVALUATION OF LINES, SALINAS, CA., 1997

(cont.)

Variety	Description	Powdery Mildew			Harvest		Stand		Erwinia			
		07/11	07/17	07/28	Mean	Count	Count	Mean	Count	Rating	DI	%R
mm, S <sup>f</sup> , Aa Populations and Lines (cont.)												
Block 10												
6819M	RZM 5819M, C890-9 (WB151)	3.0	3.7	6.3	4.3	17	18	18	26.7	51.9		
6820M	RZM 5278M, C890-10 (WB169)	1.7	3.3	6.7	3.9	17	17	17	23.2	46.4		
6821M	RZM 5279M, C890-11 (WB258)	2.0	3.0	6.7	3.9	19	24	24	17.3	47.5		
6828m	RZM 5828-3, -6, -12, -13mm	3.3	4.0	6.7	4.7	20	20	20	21.4	43.4		
US H11	L113401	2.7	3.7	6.7	4.3	22	22	22	7.0	73.2		
E840	Inc. C40 BTS	3.3	4.7	7.0	5.0	20	20	20	70.6	24.9		
6831-4	RZM T-O sel., 4831-4mmØ	2.0	2.3	6.0	3.4	18	18	18	19.0	68.8		
6833m	RZM 5833-#'s(C)mm	3.0	3.7	7.0	4.6	20	20	20	18.2	59.3		
6833%M	RZM-%S 4833%M	2.7	3.7	7.3	4.6	21	21	21	6.7	86.6		
6833%M	RZM-%S 4833%mm	2.7	3.0	6.7	4.1	23	22	22	19.7	67.5		
6834%M	RZM-%S 4834%M	2.3	3.7	7.0	4.3	20	19	19	17.4	48.7		
6834m	RZM-%S 4834%mm	2.0	3.3	7.3	4.2	22	22	22	10.0	74.5		
6836M	RZM 5911-4-#, 5829-#, 5830-#, 5831-#M	2.3	3.3	6.3	4.0	21	20	20	15.8	79.3		
6837m	T-O sel. RZM 5911-4-#, 5829-#, 5830-#, 5831-#, 5832-#mm	1.3	3.0	6.3	3.6	20	20	20	20.2	57.8		
6859-8M	Inc. 2859MA(sp) -8	2.0	2.7	6.7	3.8	20	21	21	23.7	67.4		
6891-10m	Inc. 2891MA(sp) -10	2.3	3.0	6.7	4.0	21	21	21	23.8	42.3		
Mean		2.0	2.9	6.3	3.8	20.3	20.4	20.4	18.1	65.4		
LSD (.05)		1.2	1.3	1.2	0.9	3.3	3.3	3.3	11.5	18.5		
C.V. (%)		35.6	28.3	11.6	14.7	10.1	10.2	10.2	39.6	17.6		
F value		4.0**	3.7**	3.8**	6.3**	1.6**	1.6**	1.6**	18.9**	8.1**		

NOTES: \* = increased in common plot, so line intercrossing may have occurred. See notes for Test 1497.

100 entries x 3 replications, sequential  
1-row plots, 17 ft. long

Planted: March 7, 1997  
Scored: October 10, 1997  
Inoc. Ecb: July 11, 1997

Variety	Description	Powdery Mildew			Harvest		Stand		Erwinia				
		07/11	07/17		07/28	Mean	Count	Mean	Count	Rating	DI	%R	
Block 1													
US H11	L111102 (9-24-96) (ERR susc.ck.)	2.7	3.0	6.0	3.9	23	22	22	8.7	79.8			
C40	BTS Inc. C40 (ERR susc.ck.)	1.7	4.0	7.3	4.3	20	20	20	86.6	10.7			
E840H72	U83-718HO x C40	2.3	3.7	6.3	4.1	22	23	23	51.8	35.8			
E840H8	F82-546H3 x C40	2.0	3.3	7.0	4.1	21	22	22	28.0	54.8			
SS-781R	SS,L941000,9-4-96	3.0	3.0	6.3	4.1	21	22	22	21.6	63.5			
Rival	HH103, 8-29-95	2.7	4.0	7.7	4.8	23	22	22	10.8	76.3			
4776R	BTS, 2-20-97, 4776.6102	1.0	2.3	7.0	3.4	27	25	25	3.8	92.6			
4454	BTS, 2-20-97, 4454.6382	1.7	2.0	6.0	3.2	21	20	20	5.1	82.1			
Monohikari	Seedex, 2-18-97	1.0	3.3	6.3	3.6	23	23	23	3.5	92.7			
ACH 205	American Crystal, 2-18-97	1.0	2.7	6.3	3.3	22	23	23	4.0	85.7			
HM55	Hilleshog, 2-18-97	0.3	3.0	6.7	3.3	22	24	24	6.2	83.7			
HM1605	Hilleshog, 2-18-97	1.0	3.0	5.7	3.2	23	22	22	8.3	81.2			
SX-02	Seedex, 2-18-97	2.3	2.7	7.0	4.0	21	21	21	7.0	87.9			
B1399	Betaseed, 2-18-97	3.0	2.7	7.0	4.2	22	22	22	3.6	88.1			
Canyon	Hilleshog, 8-8-96	1.0	4.0	8.3	4.4	22	21	21	19.1	70.3			
WS91	Hilleshog, 8-8-96	1.7	3.3	7.3	4.1	20	21	21	24.1	59.3			
6913-70H50	F92-790-15CMS x 5913-70 (C913-70)	2.3	2.3	5.7	3.4	21	23	23	4.7	87.6			
6911-4-10H50	F92-790-15CMS x RZM 4911-4-10M	2.3	2.3	6.3	3.7	22	23	23	23.2	56.7			
6915-7-6H50	F92-790-15CMS x RZM 4915-7-6	1.7	1.7	5.0	2.8	22	23	23	5.2	83.6			
6918-3H50	F92-790-15CMS x RZM 4918-3	1.3	2.0	5.7	3.0	24	24	24	4.1	84.9			
6918-12H50	F92-790-15CMS x RZM 4918-12	1.7	1.7	5.0	2.8	22	23	23	11.4	70.4			
6918-21H50	F92-790-15CMS x RZM 4918-21	2.0	1.7	5.7	3.1	22	23	23	17.3	74.4			
US H11	L111102, 9-24-96	1.3	3.0	6.3	3.6	20	20	20	7.6	81.0			
C40	Inc. C40	1.0	3.7	7.0	3.9	21	22	22	76.9	16.1			

TEST 1497. ERWINIA/POWDERY MILDEW EVALUATION OF HYBRIDS, SALINAS, CA., 1997

(cont.)

Variety	Description	Powdery Mildew			Harvest Count	Stand Count	Erwinia Rating	
		07/11	07/17	07/28			Mean	DI
Block 1 (cont.)								
6921H50	F92-790-15CMS x RZM-8S R21(C)	1.3	2.0	6.0	3.1	21	20	22.0 68.3
6931H50	F92-790-15CMS x RZM 931(C)	1.3	2.0	5.7	3.0	21	21	8.8 76.9
6931H70	5869HO x RZM 931(C)	2.0	3.0	6.3	3.8	20	20	9.0 79.5
Y671H50	F92-790-15CMS x Y71(C)	1.7	3.0	6.0	3.6	20	21	13.2 74.8
6913-70H52	F92-790-15H39 x 5913-70 (C913-70)	1.7	2.7	5.3	3.2	23	23	2.0 94.6
6913-70H37	4807HO(C306/2CMS) x 5913-70	1.7	2.3	5.7	3.2	23	22	8.2 88.2
6913-70H39	91-762-17CMS x 5913-70	2.3	2.3	6.0	3.6	20	21	2.6 85.4
6913-70H70	6869HO x 5913-70	2.0	3.0	6.0	3.7	22	21	2.2 94.0
R678H50	F92-790-15CMS x R578(sp) (C78)	2.3	2.3	6.7	3.8	21	21	14.8 68.9
R678H50NB	5790-15CMS x R578(sp)	2.3	2.3	5.3	3.3	21	21	21.0 60.4
R678H50-21	5790-15-21CMS x R578(sp)	1.7	2.0	5.7	3.1	21	21	26.5 57.9
R678H50-23	5790-15-23CMS x R578(sp)	3.0	2.7	6.7	4.1	21	21	12.8 75.0
R678H39	91-762-17CMS x R578(sp)	2.3	3.0	6.7	4.0	23	20	7.5 82.8
R678H72	U83-718HO x R578(sp)	2.0	2.3	7.3	3.9	21	21	17.2 65.3
R678H7	5911-5-7CMS x R578(sp)	2.3	2.3	6.0	3.6	20	21	16.1 73.2
R678H70	5869HO x R578(sp)	4.3	3.3	7.0	4.9	22	22	13.3 72.1
R678H68	5867HO x R578(sp)	2.0	3.0	6.3	3.8	21	22	15.3 78.3
R678H68NB	5867NBHO x R578(sp)	2.3	2.7	6.3	3.8	20	20	16.7 75.4
R678H87	5890aa x R578(sp)	2.7	2.3	7.0	4.0	21	21	16.3 77.0
R678H34	5834aa x R578(sp)	3.0	3.3	7.0	4.4	21	22	16.2 64.6
R678H59	5859%aa x R578(sp)	2.3	3.0	6.3	3.9	20	20	19.0 68.6
R678H95	5895aa x R578(sp)	1.3	3.3	7.0	3.9	20	19	12.6 73.4
R678H5	Z325aa x R578(sp)	1.7	3.0	7.0	3.9	19	19	8.0 75.5
R678H11M	5911-4Maa x R578(sp)	1.7	2.3	6.0	3.3	19	18	6.6 84.4
US H11	L111102 (11-16-94)	2.7	3.0	7.0	4.2	22	22	5.5 83.6
C40	Inc. C40	3.0	4.7	8.0	5.2	21	22	87.9 11.0
R678H67-1	2867mA(sp) -1aa x R578(sp)	3.3	2.7	6.3	4.1	21	22	13.9 67.0
R678H59-8	2859mA(sp) -8aa x R578(sp)	1.7	2.7	7.0	3.8	20	20	29.5 39.6



(cont.)

Variety	Description	Powdery Mildew			Harvest Count	Stand Count	Erwinia		
		07/11	07/17	07/28			Mean	DI	%R
Block 1 (cont.)									
R678H91-10	2891mA (Sp) -10aa x R578 (Sp)	2.3	3.0	7.0	4.1	19	20	17.0	54.1
R678H33-1	5833-1aa x R578 (Sp)	2.3	3.7	6.3	4.1	17	17	29.6	43.8
R678H33-2	5833-2aa x R578 (Sp)	3.7	4.0	7.0	4.9	20	21	23.7	58.5
R678H33-4	5833-4aa x R578 (Sp)	2.7	2.3	6.3	3.8	21	22	10.2	82.4
R678H33-5	5833-5aa x R578 (Sp)	1.7	3.0	6.3	3.7	21	21	21.5	59.6
R678H33-6	5833-6aa x R578 (Sp)	2.3	3.0	6.3	3.9	20	20	28.3	51.9
R678H33-8	5833-8aa x R578 (Sp)	2.7	2.7	6.3	3.9	21	21	15.4	66.7
R678H33-12	5833-12aa x R578 (Sp)	2.0	3.3	7.0	4.1	22	22	18.8	62.3
R678H33-13	5833-13aa x R578 (Sp)	4.3	3.7	7.3	5.1	21	21	13.8	71.3
R678H33-14	5833-14aa x R578 (Sp)	3.0	2.7	6.0	3.9	20	20	11.5	74.6
R678H33-15	5833-15aa x R578 (Sp)	1.3	2.7	6.3	3.4	17	16	16.1	73.0
R678H33-17	5833-17aa x R578 (Sp)	2.7	3.0	6.3	4.0	21	22	22.4	54.1
R678H33-19	5833-19aa x R578 (Sp)	2.0	3.7	6.3	4.0	17	17	14.8	68.3
R680H50	F92-790-15CMS x RZM R580, NB	4.0	2.7	5.7	4.1	22	21	18.8	61.7
R680H7	5911-4-7CMS x RZM R580, NB	2.3	2.0	5.3	3.2	21	19	14.0	71.9
R680H37	4807HO (C306/2CMS) x RZM R580, NB	3.7	3.3	6.7	4.6	21	22	22.0	68.9
R680H70	5869HO x RZM R580, NB	2.0	2.7	6.3	3.7	21	21	8.4	82.4
US H11	11-16-94	2.3	3.3	7.3	4.3	23	23	2.3	92.0
C40	Inc. C40	3.0	4.0	7.0	4.7	22	24	85.4	13.4
R680H11-3	5911-4-3aa x RZM R580, NB	3.0	3.3	6.7	4.3	20	19	7.2	68.3
R680H11-5	5911-4-5aa x RZM R580, NB	2.3	2.0	5.0	3.1	16	16	31.0	52.3
R680H29-2	5829-2aa x RZM R580, NB	1.7	3.0	6.3	3.7	21	21	12.8	68.4
R680H29-3	5829-3aa x RZM R580, NB	2.3	2.7	6.3	3.8	21	20	21.9	64.4
R680H29-4	5829-4aa x RZM R580, NB	1.7	4.0	7.0	4.2	20	21	15.8	73.1
R680H29-5	5829-5aa x RZM R580, NB	2.3	3.0	6.0	3.8	19	20	6.4	87.4
R680H27-7	5829-7aa x RZM R580, NB	3.0	3.3	7.0	4.4	22	21	10.8	83.4
R680H30-1	5830-1aa x RZM R580, NB	3.0	2.3	6.3	3.9	21	22	5.9	82.8
R680H30-2	5830-2aa x RZM R580, NB	2.7	2.7	5.7	3.7	19	19	9.3	84.1

TEST 1497. ERWINIA/POWDERY MILDEW EVALUATION OF HYBRIDS, SALINAS, CA., 1997

(cont.)

Variety	Description	Powdery Mildew			Harvest Count	Stand Count	Erwinia Rating	
		07/11	07/17	07/28			Mean	DI
Block 1 (cont.)								
R680H30-3	5830-3aa x RZM R580,NB	3.0	3.0	7.0	4.3	20	10.4	66.8
R680H31-2	5831-2aa x RZM R580,NB	1.0	3.3	6.0	3.4	22	8.7	83.5
R680H31-3	5831-3aa x RZM R580,NB	1.7	2.7	6.3	3.6	20	29.6	61.4
R680H31-4	5831-4aa x RZM R580,NB	2.7	2.3	5.7	3.6	21	10.0	74.8
R680H31-5	5831-5aa x RZM R580,NB	3.0	2.7	6.7	4.1	20	23.5	67.9
R680H31-6	5831-6aa x RZM R580,NB	2.3	2.7	5.7	3.6	22	7.0	81.7
R680H31-7	5831-7aa x RZM R580,NB	3.7	2.7	6.3	4.2	21	2.4	93.8
R680H31-8	5831-8aa x RZM R580,NB	2.0	3.3	6.7	4.0	21	16.2	65.5
R680H31-9	5831-9aa x RZM R580,NB	2.3	3.0	6.3	3.9	21	15.1	75.2
US H11	11-16-94	1.7	3.7	7.0	4.1	22	7.9	81.4
C40	Inc. C40	2.7	4.0	7.3	4.7	21	84.8	9.8
R680H31-10	5831-10aa x RZM R580,NB	2.0	2.3	5.0	3.1	22	14.8	76.7
R680H31-11	5831-11aa x RZM R580,NB	1.7	2.7	6.0	3.4	21	17.4	71.3
R680H32-1	5832-1aa x RZM R580,NB	1.3	3.3	6.7	3.8	17	11.6	73.3
R680H32-2	5832-2aa x RZM R580,NB	1.7	3.3	7.0	4.0	20	11.6	69.8
R680H32-3	5822-3aa x RZM R580,NB	2.0	3.0	5.7	3.6	21	18.5	63.3
R680H32-5	5832-5aa x RZM R580,NB	1.7	3.3	7.0	4.0	24	35.0	54.8
R680H32-7	5832-7aa x RZM R580,NB	2.0	2.7	6.7	3.8	20	17.8	75.0
R678H10	5810aa x R578 (Sp)	1.7	2.7	6.3	3.6	21	17.6	72.2
R680H88	5890HO x RZM R580,NB	1.3	2.0	5.7	3.0	23	8.9	77.9
Mean		2.2	2.9	6.4	3.8	21.0	21.1	17.7
LSD (.05)		1.3	0.9	0.9	0.6	3.2	3.1	11.7
C.V. (%)		36.4	18.4	8.9	9.5	9.4	9.1	41.0
F value		2.7**	3.8**	3.9**	5.5**	1.8**	2.1**	17.4*
								6.4**

NOTE: 5833-#'s, 5911-4-#'s, 5829-#'s, 5830-#'s, 5831-#'s, & 5832-#'s are monogerm,Rz,S<sub>1</sub> lines topcrossed to a pollinator. Powdery mildew scored on a scale of 0-9 where 9 = highly susceptible. Erwinia rated on a scale from 0-100 where 100 = 100% rotted/dead and DI = average rot per root; %R = percentage of roots with less than 8% rot.

TEST 5797. RHIZOMANIA EVALUATION OF PLANT INTRODUCTIONS, BLOCK 2S(E), SALINAS, CA., 1997

32 entries x 3 replications, sequential  
1-row plots, 13 ft. long

Planted: May 8, 1997

Harvested: November 13, 1997

Variety	Description	Acre Yield		Beets/ 100'	RJAP %	Bolting %	Rhizomania DI	%R
		Sugar Lbs	Beets Tons					

Salinas entries & checks

US H11	113102, 3-18-97	2407	12.45	195	69.7	0.0	5.8	12.6
R639	RZM R539, C39R	5413	21.79	187	72.3	0.0	2.9	81.1
SP7622-0	Inc. SP6822-0, 8-87	1861	9.99	113	67.3	0.0	5.0	27.1
R626	RZM R526	4606	18.55	190	83.1	0.0	3.3	81.4

USDA entries

PI380754	Iran, Beta spp.	455	6.73	123	44.1	0.0	5.4	0.0
PI502293	Uzbekistan, Beta spp.	898	17.35	182	41.8	0.0	5.1	24.6
Ames 2632	US, Utah, B.vulgaris	2946	15.39	151	69.6	0.0	5.1	18.4
Ames 2633	US, Utah, B.vulgaris	2983	12.33	100	76.6	0.0	5.5	18.2
Ames 2651	US, Utah, B.vulgaris sugarbeet	3579	17.83	192	65.1	0.0	3.1	76.6
Ames 8279	UK, England, B.vulgaris							
Ames 8284	UK, England, B.vulgaris							
Ames 8291	UK, England, B.vulgaris							
Ames 8292	UK, England, B.vulgaris	506	4.69	87	47.4	0.0	5.5	0.0
PI470092	UK, England, B.vulgaris	3414	17.35	185	73.4	0.0	4.8	27.3
PI470093	Hungary, B.vulgaris	2368	13.40	164	67.6	0.0	5.2	21.4
PI470094	US, B.vulgaris	2648	15.32	169	64.5	0.0	5.0	28.9
PI470095	Hungary, B.vulgaris	2817	15.08	164	71.5	0.0	5.4	18.9
PI518165	China, B.vulgaris monogerm	2454	9.45	192	75.5	0.0	4.5	39.7
PI414934	South Africa, B.v.v.	1312	8.99	115	48.7	0.0	5.6	16.7
PI505830	Former Soviet Union, B.v.v.	3384	18.31	179	76.9	0.0	5.0	30.8
PI535842	Poland, B.v.v. (maritima)	2313	9.69	156	71.1	1.8	3.8	53.3
PI504273	France, B.v.m.							

TEST 5797. RHIZOMANIA EVALUATION OF PLANT INTRODUCTIONS, BLOCK 2S(E), SALINAS, CA., 1997

(cont.)

Variety	Description	Acre Yield		Beets/ 100'	Sucrose %	RJAP %	Bolting %	Rhizomania	
		Sugar	Beets					DI	%R
		Lbs	Tons						
Salinas entries & checks (cont.)									
US H11 R639	113102, 3-18-97	2905	13.52	174	10.70	76.7	0.0	5.3	18.9
	RZM R539, C39R	6808	26.57	179	12.83	75.2	0.0	2.8	85.8
SP7622-0 R626 R522 (Sp) 6921 (Sp)	Inc. SP6822-0, 8-87	1827	10.85	133	8.93	62.0	0.0	4.6	32.0
	RZM R526	2795	12.33	177	11.37	70.9	3.2	3.4	71.6
	RZM-%S	6149	24.53	161	12.57	75.5	0.0	2.7	89.7
	RZM-%S R21	5770	22.02	161	13.07	74.2	0.0	2.9	87.5
Y671 (Iso) R678 (Iso) Y669 6913-70 (Sp)	RZM 5205, P;...	6584	25.85	174	12.77	76.6	0.0	3.5	74.9
	NB-RZM R478NB, C78	5578	20.22	174	13.83	76.8	0.0	3.3	68.8
	RZM Y569	7324	25.37	161	14.43	81.1	0.0	3.8	68.2
	5913-70aa x A, (C913-70)	4217	16.63	208	12.70	71.3	0.0	3.1	84.8
Mean		3440.1	15.81	162.5	10.24	68.8	0.2	4.3	45.0
LSD (.05)		1715.3	6.48	36.5	2.00	12.4	1.3	0.8	21.9
C.V. (%)		30.5	25.04	13.7	11.93	11.0	436.9	11.5	29.7
F value		10.1**	6.65**	5.6**	17.54**	6.2NS	2.3**	13.3**	15.2**

US H11 = rhizomania susceptible check. R639 = C39R = rhizomania and BWVY resistant check. SP7622-0 = SP6822-0 = SP22-0 = rhizomania and BWVY susceptible check. R626 = F<sub>3</sub>(C37 x B.v.m.); Bvm from rhizomania resistant selections among PI lines evaluated from U.K. RE522 = C51 = Cycle 5 for selection against rhizomania from sugarbeet x B.v.maritima. 6921 = sugarbeet x C51. Y671 = sugarbeet x C51. C78 has Rz resistance to rhizomania. Y669 = C69 released in 1997 with Rz resistance. 6913-70 = C913-70 = Increase of one S<sub>1</sub> line with Rz.

Note: Lines without yield data were annual and pulled mid-season, rated on a whole plot basis for reaction to rhizomania, and destroyed.

RJAP = raw juice apparent purity = %S/%soluble solids.

Rhizomania rated on a scale of 0 to 9 where 9 = dead. DI = mean individual plant rating; %R = % resistant = classes 0 to 3/ total.

(cont.)

P.I. # Variety	Harvest Count	Type	End Use	Ring Color	Flesh Color	Petiole Color	Bolting Tendency	BWV	Habit	RZM	CLS	Powdery Mildew
US H11	23	6	5			1		3	1		5	6.3
R639	24	6	5			1		3	1		5	5.0
SP7622-0	15	6	5			1		5	1		4	6.7
R626	24	6	5			1		3	1		4	8.3
PI380754	8	6	5			1		5	1		8	5.3
PI502293	19	6	5	2	2	1	1	5	1	3	6	5.3
Ames 2632	15	6	5			2		5	1		6	5.3
Ames 2633	14	6	5			3		6	1		5	6.0
Ames 2651	25	6	5			1		4	1		7	6.0
Ames 8279	0	6	7			1		3	1		7	7.7
Ames 8284	0	6	7			3		4	1		6	5.3
Ames 8291	0	6	7	2	1	1	9	3		6		7.7
Ames 8292	4	6	2	2	1	4	9	5	2	6	8	4.7
PI470092	24	6	5	2	1	1	9	4	1	8	6	6.0
PI470093	21	6	5			1		4	1		5	5.0
PI470094	22	6	5			1		5	1		7	5.7
PI470095	20	6	5			1		4	1		6	4.7
PI518165	23	6	5			1		4	2		5	6.0
PI414934	12	7	2			3		3	2		4	4.7
PI505830	18	6	5			1		4	1		7	4.7
PI535842	18	8	7	1	4	1	4	3	2	7	5	6.3
PI504273	0	5	7			4		3	1		5	5.7
US H11	21	6	5			1		4	1		5	5.7
R639	24	6	5	2	1	1	6	3	1	6	5	4.7

TEST 5797. RHIZOMANIA EVALUATION OF PLANT INTRODUCTIONS, BLOCK 2S(E), SALINAS, CA., 1997

(cont.)

P.I. # Variety	Harvest Count	Type	End Use	Ring Color	Flesh Color	Petiole Color	Bolting Tendency	BWV	Habit	RZM	CLS	Powdery Mildew
SP7622-0	17	6	5			1		5	1		4	5.7
R626	24	6	5			1		3	1		4	8.0
R522 (Sp)	24	6	5			1		3	1		5	7.7
6921 (Sp)	23	6	5			1		3	1		5	6.3
Y671 (Iso)	24	6	5			1		3	1		5	6.0
R678 (Iso)	24	6	5			1		3	1		5	6.3
Y669	23	6	5			1		3	1		4	4.7
6913-70 (Sp)	24	6	5			1		4	2		4	5.0

NOTES:

Type: 1 = chard; 2 = fodder; 3 = FS; 4 = leaf; 5 = red; 6 = sugar; 7 = table; 8 = wild.

End Use: 1 = leaf veg.; 2 = root veg.; 3 = leaf & root veg.; 4 = fodder; 5 = sugar extraction; 6 = biomass  
7 = use unknown; 8 = other.

Ring Color: 1 = white; 2 = yellow; 3 = orange; 4 = red; 5 = purple.

Flesh Color: 1 = white; 2 = yellow; 3 = orange; 4 = red; 5 = purple.

Petiole Color: 1 = green; 2 = pink; 3 = red; 4 = mixed; 5 = yellow.

Bolting Tendency: 1 = 0-11%; 2 = 11-22; 3 = 22-34; 4 = 34-45; 5 = 45-56; 6 = 56-67; 7 = 67-78; 8 = 78-90;  
9 = 90-100%.

BWV (Beet Western Yellows Virus): 0 = immune; 1 = very resist.; 2,3,4 = resistant; 5,6 = intermediate;  
7,8 = susceptible; 9 = highly susceptible.

Habit: 1 = erect; 2 = intermediate bet 1-3; 3 = procumbent; 4 = intermediate bet 3-5; 5 = prostrate (no more  
than 6" high).

Rhizomania: 0 = immune; 1 = very resist.; 3 = resistant; 5 = intermediate; 7 = susceptible; 9 = highly susc.

CLS = Cercospora leaf spot. A mild infection occurred and rated 0 to 9 where 9 = complete defoliation.

Powdery mildew rate 0 to 9 where 9 = highly susceptible.

DAVIS-1. VIRUS YELLOWS RESISTANCE EVALUATION OF BREEDING LINES & POTENTIAL SOURCES OF RESISTANCE,  
DAVIS, CA., 1996

12 varieties x 2 virus trtmts x 6 reps., Split-plot  
1-row plots, 30 ft. long

Planted: May 14, 1996  
Harvested: October 14, 1996  
BYV-BWYV-CRV Inoc.: June 21, 1996

Varieties (V)	Description	Acre Yield				Clean					
		Sugar (lbs)		Beets (t)		Sucrose (%)		Beets (%)			
		Inoc.	Noninoc.	Inoc.	Noninoc.	Inoc.	Noninoc.	Inoc.	Noninoc.		
Hybrid Checks											
1. Rival	Holly Hybrids	4195	7938	16.41	28.90	12.77	13.73	93.6	96.0	117	111
2. 4454	Betaseed	4585	8456	17.33	29.53	13.25	14.32	93.2	94.1	105	95
Sources of Resistance											
3. 5915	C918	5305	8442	20.84	30.33	12.73	13.92	92.7	95.3	85	68
4. R578	C78	5485	8249	20.83	29.27	13.25	14.08	92.5	93.9	67	51
5. R581	C82	4667	8893	18.58	33.13	12.50	13.45	94.0	95.4	102	99
6. R522	C51	4188	7053	17.15	26.23	12.22	13.45	90.3	93.3	98	73
Breeding Lines in Selection Plot											
7. R578H18	C918 x C78	6235	8581	23.50	30.76	13.27	13.95	93.7	94.3	69	63
8. R581H18	C918 x C82	6048	8723	23.84	32.45	12.72	13.45	94.6	95.3	82	101
9. R576-89-18H18	C918 x C76-89-18	6189	9168	23.37	32.33	13.23	14.20	94.0	95.0	68	59
10. 5921H18	C918 x C51	6159	8055	23.26	29.47	13.20	13.65	93.2	94.1	73	77
11. 5923		5304	8375	20.57	30.56	12.88	13.70	92.9	94.0	63	57
12. 5924		5632	8527	20.82	30.73	13.50	13.88	94.0	95.2	73	71
Virus treatment means											
		5333	8372	20.54	30.31	12.96	13.82	93.2	94.6	83	77
Grand Mean											
C.V. (%)	- T x V	6852.1	25.42	13.39	93.9	80.2					
LSD (.05)	- T	13.6	13.52	3.24	1.3	24.0					
LSD (.05)	- V	**	**	**	**	NS					
LSD (.05)	- T x V	1791.0	6.16	0.98	2.7	56.1					
F value	- T	1432.0	5.12	0.58	1.8	24.3					
F value	- V	375.8**	237.63**	525.85**	11.6*	1.8NS					
F value	- T x V	4.6**	3.98**	6.29**	6.1**	10.5**					
F value	- T x V	1.5NS	1.37NS	1.10NS	1.3NS	1.0NS					

DAVIS-1. VIRUS YELLOWS RESISTANCE EVALUATION OF BREEDING LINES & POTENTIAL SOURCES OF RESISTANCE,  
DAVIS, CA., 1996

(cont.)

Varieties (V)	Description	Recover.		Sugar (%)		Sodium (ppm)		Potassium (ppm)		NH <sub>2</sub> -N (ppm)	
		Sugar (lbs)		Sugar (%)		Sodium (ppm)		Potassium (ppm)		NH <sub>2</sub> -N (ppm)	
		Inoc.	Noninoc.	Inoc.	Noninoc.	Inoc.	Noninoc.	Inoc.	Noninoc.	Inoc.	Noninoc.
Hybrid Checks											
1. Rival	Holly Hybrids	3598	6866	85.8	86.5	587	627	2282	2389	457	444
2. 4454	Betaseed	3906	7409	85.3	87.6	600	557	2515	2345	484	427
Sources of Resistance											
3. 5915	C918	4495	7468	84.7	88.4	649	486	2600	2209	440	369
4. R578	C78	4749	7176	86.8	87.0	567	534	2127	2424	451	445
5. R581	C82	3978	7713	85.2	86.8	819	612	2284	2284	397	421
6. R522	C51	3547	6026	84.7	85.4	605	615	2335	2492	476	496
Breeding Lines in Selection Plot											
7. R578H18	C918 x C78	5393	7504	86.4	87.5	536	495	2326	2246	459	451
8. R581H18	C918 x C82	5196	7592	85.9	87.0	575	567	2291	2335	439	403
9. R576-89-18H18	C918 x C76-89-18	5338	8023	86.2	87.5	478	434	2456	2433	457	449
10. 5921H18	C918x C51	5361	6970	86.9	86.5	591	526	2236	2644	407	404
11. 5923		4513	7264	85.1	86.7	577	513	2533	2411	465	451
12. 5924		4949	7431	87.5	87.2	608	540	2144	2395	386	420
Virus treatment means											
		4585	7287	85.9	87.0	599	542	2344	2384	443	432
Mean											
C.V. (%)	- T x V	5936.1		86.4		570.7		2363.9		437.3	
LSD (.05)	- T	14.0		1.6		22.0		9.8		15.3	
LSD (.05)	- V	**		**		**		NS		NS	
LSD (.05)	- T x V	1639.0		1.9		190.7		239.4		85.8	
F value	- T	1314.0		2.5		150.7		487.7		68.3	
F value	- V	412.7**		27.3**		3.5NS		1.6NS		0.7NS	
F value	- T x V	4.8**		2.2*		2.9**		1.3NS		2.0*	
F value	- T x V	1.6NS		1.9*		0.9**		2.7**		0.6NS	



The Evaluation of Molecular and Serological Relationships Among Sugar Beet Furoviruses in the United States and Their Application Toward an Improved Soil Test for Diagnosis of BNYVV: Levels Of Beet Necrotic Yellow Vein Virus Among Resistant And Susceptible Sugar Beet Cultivars Grown In Naturally Infested Soil.

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Projects 203 & 280, 281

### Introduction

Rhizomania of sugar beet is an economically important disease caused by the beet necrotic yellow vein furovirus (BNYVV). BNYVV is vectored by the protozoan *Polymyxa betae* (Barr, 1992; Margulis, 1988) and survives in infested soil for many years in thick-walled resting structures called cystosori (Abe & Tamada, 1986; Abe and Ui, 1986). Typical symptoms of rhizomania include a constricted taproot referred to as a "wineglass" shape, with a proliferation of feeder roots (called "bearding") which appear brown due to the infestation of darkly-colored cystosori and root cell death. In severe infections, taproots show necrosis in the vascular system, or roots can be destroyed which can result in death of the beet. Even in light infestations with rhizomania, sugar content and root yields are depressed. Foliar symptoms appear as chlorotic patches in the field which may correspond to the movement of soil by cultivation equipment.

Control of rhizomania includes avoidance of infested fields by testing soil for BNYVV prior to planting, fumigation or solarization of soil where permitted, and the use of resistant cultivars (Lewellen & Wrona, 1997). A wide range of sugar beet cultivars have been developed with varying degrees of resistance, or tolerance to rhizomania. Previous studies in England (Asher & Kerr, 1996; Asher et al., 1997) and the Netherlands (Tuitert et al., 1994) showed that sugar beet cultivars with different levels of resistance vary in the levels of BNYVV detected in the roots. Because infected lateral roots remain in the soil after harvest and viruliferous cystosori survive until the next crop is planted, it is important to plant varieties which would not contribute to increasing levels of BNYVV.

Rhizomania was first recognized in the United States in 1983 in Paso Robles, California (Duffus & Liu, 1987; Duffus et al., 1984). Since then, the disease has become widespread throughout California where sugar beet is grown (Wisler et al., 1994b). After it was found in California, rhizomania was detected in Texas (Duffus and Liu, 1987), Idaho, Colorado, and Nebraska (Wisler et al., 1994a). More recently, in 1996, rhizomania was diagnosed in southern Minnesota (Wisler, et al., 1997). Growers have been reluctant to plant rhizomania resistant seed because of lower yields and decreased resistance to other diseases typically associated with these cultivars. However, in newly infested areas like Minnesota, growers have started to use rhizomania resistant cultivars because those recently developed now have the yield potential of nonresistant cultivars and are suited to their production conditions.

Resistance to rhizomania in most commercial sugar beet cultivars is conditioned by the dominant allele Rz (Lewellen et al., 1987) as well as by quantitative factors (Lewellen and Biancardi, 1990) that appears also to modify the expression of Rz. A number of sugar beet cultivars with varying degrees of resistance to rhizomania based on different genetic

backgrounds have been developed for the diverse production conditions throughout the United States where beets are grown (Lewellen, et al., 1987).

The purpose of this study was to evaluate the BNYVV content in representative commercial and experimental sugar beet cultivars developed for production in the United States. Cultivars selected ranged in their reactions to rhizomania from uniformly susceptible to highly resistant. Cultivars selected for evaluation represent commercial and experimental lines that are used in sugar beet growing areas in the U.S. Selection of rhizomania resistant parental lines of cultivars in the U.S. is based on their field performance, which includes symptom evaluation and on analyses for sugar content and root yield. In Europe selections are made by measuring virus content in ELISA tests from sugar beet seedlings grown under controlled conditions in greenhouses and growth rooms.

Tests were conducted at the USDA-ARS in Salinas, California, in uniformly infested fields where continuous rhizomania resistance trials have been ongoing since 1984. As varieties are improved the selection of seed changes and new varieties with higher resistance, root yield and sugar replace those from previous years.

Efforts were made to develop an ELISA test which would show a wide range of BNYVV levels in infected roots, and would not cross-react with other furoviruses which can cause a misdiagnosis of BNYVV (Wisler et al., 1994b; 1995). The triple antibody sandwich (TAS)-ELISA, using a combination of a polyclonal antiserum (PAb) developed to the *E. coli* expressed BNYVV capsid protein (CP) and a monoclonal antibody (MAb) to BNYVV was modified for this study in collaboration with Agdia, Inc. (Elkhart, Indiana). Information regarding different levels of BNYVV in resistant cultivars is important for the sugar industry and breeding programs whereby selection of resistant cultivars with the lowest levels of BNYVV available may suppress the buildup of rhizomania in soils and may give the highest protection.

## Materials and Methods

**Sugar beet cultivars:** Sugar beet varieties were chosen to represent two geographically diverse growing areas in the United States, including California and southern Minnesota (Table 1). The cultivar 'USH11' is an obsolete commercial hybrid formerly widely grown in California. 'USH11' is known to be highly susceptible to rhizomania and has frequently been used as a susceptible check. 'KWS6770' is susceptible to rhizomania and has been grown extensively in the upper midwestern states. 'Beta4776R' is reported to be diploid and each plant is supposed to carry one dose (Rzrz) of the Rz allele. It is currently widely grown in California. 'Beta4038R' is a triploid hybrid with the same source of resistance to rhizomania as 'Beta4776R' and likewise carries a single dose of the Rz allele but genotypically is Rzrzrz. It is targeted to beet growing areas in the upper midwest and the eastern slope of the Rocky Mountains. 'HM7072' is being tested for the same areas as 'Beta4038R' and is a diploid hybrid with each plant carrying a single copy of the Rz allele. The cultivar 'Rival' has wide adaptation and is known worldwide. In addition to carrying this Rz allele, it is reported to also have the rhizomania resistance from the widely grown cultivar 'Rizor'. 'SS781R' is diploid and each plant originally was thought to carry one copy of the Rz allele. It now appears that this hybrid segregates for about 12% susceptible (rzrz) plants. 'SS781R' has been an important variety in California in rhizomania infested areas, particularly in the San Joaquin

Table 1. Sugar Beet Hybrids Used in Virus Titer Experiments Salinas, California 1997 Growing Season				
Variety	Identification	Description	Source	Genetic Description
1	USH11	susceptible	USDA-ARS	uniformly sus. rzz
2	KWS6770	susceptible	Betaseed	triploid hybrid rzzrz
3	Beta4776R	resistant	Betaseed	homogeneous Rzz
4	SS-781R	resistant	Spreckels	segregates Rzz:rzz
5	Rival	resistant	Holly	diploid res. Rzz
6	HM7072	resistant	Novartis	diploid res. Rzz
7	Beta4038R	resistant	Betaseed	triploid res. Rzzrz
8	6921H50	experimental	USDA-ARS	diploid; <i>B. maritima</i>

Valley. '6921H50' is an experimental hybrid developed by the USDA-ARS at Salinas and carries less than 50% frequency of both the Rz allele and resistance of unknown inheritance from *Beta vulgaris* spp. *maritima* sources (Lewellen, 1993).

**Serological Analysis of BNYVV:** Previous studies have shown that polyclonal antisera to BNYVV cross-react slightly with beet soil-borne mosaic virus (BSBMV), another furovirus infecting sugar beet in both ELISA tests and in western blot analyses (Wisler et al., 1995; 1996). This cross-reactivity is seen whether antisera is prepared to the purified virions or to the capsid protein (CP) which has been expressed *in vitro*. (Wisler, et al., 1995). However, the different molecular mass of the BNYVV CP (ca. 22 kDa) compared to that of BSBMV (ca. 24 kDa) allows for distinction of the two viruses in western blot assays. Monoclonal antibodies produced to BNYVV (courtesy of L. Torrance and G. Grassi) and antisera prepared to the C-terminal one third of BNVYY CP (courtesy of K. Richards) show complete specificity to BNYVV in both ELISA and western blot assays.

Although western blot analysis provides conclusive distinction between BNYVV and BSBMV, the large numbers of samples to be assayed, in addition to the need for quantitation of BNYVV content in sugar beet cultivars with different levels of resistance, necessitated the ELISA test for these studies. A triple-antibody sandwich-ELISA (TAS-ELISA) was developed in collaboration with Agdia, Inc. that would provide specificity to BNYVV in addition to the ability to obtain a wide range of absorbance values for BNYVV.

The TAS-ELISA was conducted as follows: polyclonal antiserum used as the trapping antibody was made from the BNYVV CP which was expressed *in vitro* (the clone for the BNYVV CP was kindly provided by K. Richards). The pETH plasmid expressing the CP was identified by western blot assays and was used to transform the appropriate host for expression, *E. coli* strain BL21DE3pLysS, according to Studier et al. (1990). An insoluble fusion protein of ca. 22 kDa was overexpressed and purified by SDS-PAGE as previously described (Wisler et al., 1995). Antiserum was prepared in rabbits by Berkeley Antibodies (Richmond, California). This *in vitro*-expressed BNYVV CP antiserum was used to coat microtiter plates (Immulon I; Chantilly, VA) at a 1/1000 dilution in coating buffer (0.05 M sodium carbonate, pH 9.6).

Plant samples consisted of fibrous lateral roots which had been scraped from each beet, and added to 2 ml of sample extraction buffer (phosphate-buffered saline, pH 7.2 with 0.5% Tween 20 and 0.4% dry milk powder). Root tissues were macerated using a hand held roller press (Agdia, Inc.). Expressed sap was added as paired wells to plates at 150 µl per well. A list of computer generated random numbers was used to determine the placement of the 576 test samples per harvest on 23 microtiter plates. Each plate also contained paired wells with (i) sample buffer only (ii) a rhizomania disease root and a healthy root tissues in sugar beet (*Beta vulgaris* L.) and (iii) a non-inoculated and a BNYVV-systemically infected *B. macrocarpa* leaf.

The BNYVV monoclonal antibody as the detecting antibody and the goat-anti-mouse IgG-alkaline phosphatase conjugate provided by Agdia was used according to the manufacturer's instructions. Absorbance readings ( $A_{405\text{ nm}}$ ) were made at 15 minute intervals up to 2 hr using a Bio-Tek EL312e microplate reader (Winooski, VT).

**Field Trials:** Field trials were conducted at the USDA-ARS Crop Improvement and Protection Station in Salinas, California, where rhizomania tests have been made on infested land since 1984. Test 4197 was planted 1 May 1997 in a split-plot design with eight cultivars randomized into three harvest dates (July 14, August 18, October 20) and eight replications. The plots were over-seeded and plants at the two-leaf stage were carefully thinned and singled to a spacing of 16 cm between plants. Standard best cultural practices were used including weed, insect and disease control. Sprinkler irrigation was used throughout the season and the trial field was watered at weekly intervals to field capacity. Irrigation and harvests were timed so that each harvest was made 3 days after the most recent irrigation. For the first two harvests, plots were 2.3 m long with 0.6 m alleys. Except for excluding end plants, nine beets were randomly harvested within each plot. For the third harvest, plots were 5.2 m long. Following individual plant harvest, the plots were trimmed to 3.6 m and harvested mechanically, beets were weighed and run through a standard sugar laboratory to measure sucrose concentration. Sugar yield was calculated from the product of the plot weight and sucrose concentration.

In each of the three harvests, the 9 randomly selected beets from each plot (72 plants per cultivar and 576 plants per harvest date) were dug by hand, topped just above the lowest leaf scar, and washed free of soil particles. Fibrous roots were scraped from each beet, and 0.5 g was weighed for the ELISA test. In the first harvest TAS-ELISA tests only were done. In the second and third harvests TAS-ELISA tests were done, tap roots were weighed, and each beet was scored according to a rhizomania disease index. This index was adapted using a scale of 0 to 9 to comply with the international scale for sugar beet germplasm evaluation where 0 = immunity (no visual symptoms), 1 = very resistant (nearly normal taproot and minor bearding), 3 = resistant (taproot slightly to moderately constricted, moderate bearding and taproot discoloration), 5 = intermediate (taproot wineglass shaped, feeder roots bearded, taproot discolored), 7 = susceptible (severe bearding and stunting, taproot destroyed) and 9 = highly susceptible (death of beet).

In adjacent field trials, the identical eight cultivars were evaluated for yield under similar disease and cultural practices. These trials were standard randomized complete block designs with eight replications. One-row plots were 72 cm wide and 5.2 m long. Test 3597 was hand harvested, topped, and scored for rhizomania on the 0-9 scale. Classes 0-3 were considered resistant and 4-9 susceptible. Following scoring, all beets were placed into two sample bags, washed, weighed, and run through the sugar analysis laboratory. The other field trials were mechanically harvested for yield and sugar analysis so individual beets were not scored for reactions to rhizomania (see tests 1697, 1997, and 3997 in Lewellen's section of this report).

## **Results and Discussion**

The TAS-ELISA test modified for this study gave no background cross-reactions with other furoviruses of sugarbeet, in particular, isolates of BSBMV (Table 2). One isolate each of BSBV from Texas and Minnesota gave reactions equivalent to those of healthy sugar beet roots and healthy leaf tissues of *B. macrocarpa* (Table 2). In addition, a wide range of readings were observed with different BNYVV samples of varying serial dilutions, thus providing for the ability to measure differences in BNYVV content among

resistant and susceptible sugar beet varieties.

Table 2. TAS-ELISA readings for BNYVV and BSBMV Using PAb and MAb for BNYVV

Test Sample	OD Reading ( $A_{405}$ )
BNYVV beet roots	2.227
BNYVV <i>Beta macrocarpa</i>	2.770
BSBMV-TX	0.127
BSBMV-MN	0.132
Healthy beet roots	0.153
Healthy <i>B. macrocarpa</i>	0.127

Differences in absorbance ( $A_{405}$  nm) values measured among the eight cultivars closely corresponded to a dosage effect and to the frequency of the Rz allele that conditions resistance to BNYVV (Table 3; Fig. 1). A diploid RzRz hybrid had a significantly lower value than a similar triploid RzRzRz hybrid. Cultivars that segregated RzRz:rzrz had higher absorbance values than uniformly resistant RzRz hybrids. For all cultivars, differences were observed among harvest dates, with progressively lower absorbance values measured as the season progressed. Absorbance values were significantly positively correlated with rhizomania disease index scores and negatively correlated with individual root weight, plot root weight and sugar yield (data not shown). This information is useful in resistance breeding and evaluation programs and for the sugar industry in consideration of cultivar choice, inoculum production and rotations for future cropping.

Table 3. ELISA Readings ( $A_{405}$ ) For Three Sugar Beet Harvests

Variety	July 14	August 18	October 22
1	0.927 <sup>a</sup>	0.365	0.226
2	1.007	0.414	0.341
3	0.246	0.150	0.117
4	0.325	0.164	0.140
5	0.299	0.138	0.128
6	0.205	0.111	0.138
7	0.542	0.220	0.212
8	0.339	0.192	0.155

<sup>a</sup> Values represent an average of eight replications of nine beet per rep.

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# ELISA Test Results From 7/14/97 Harvest Date

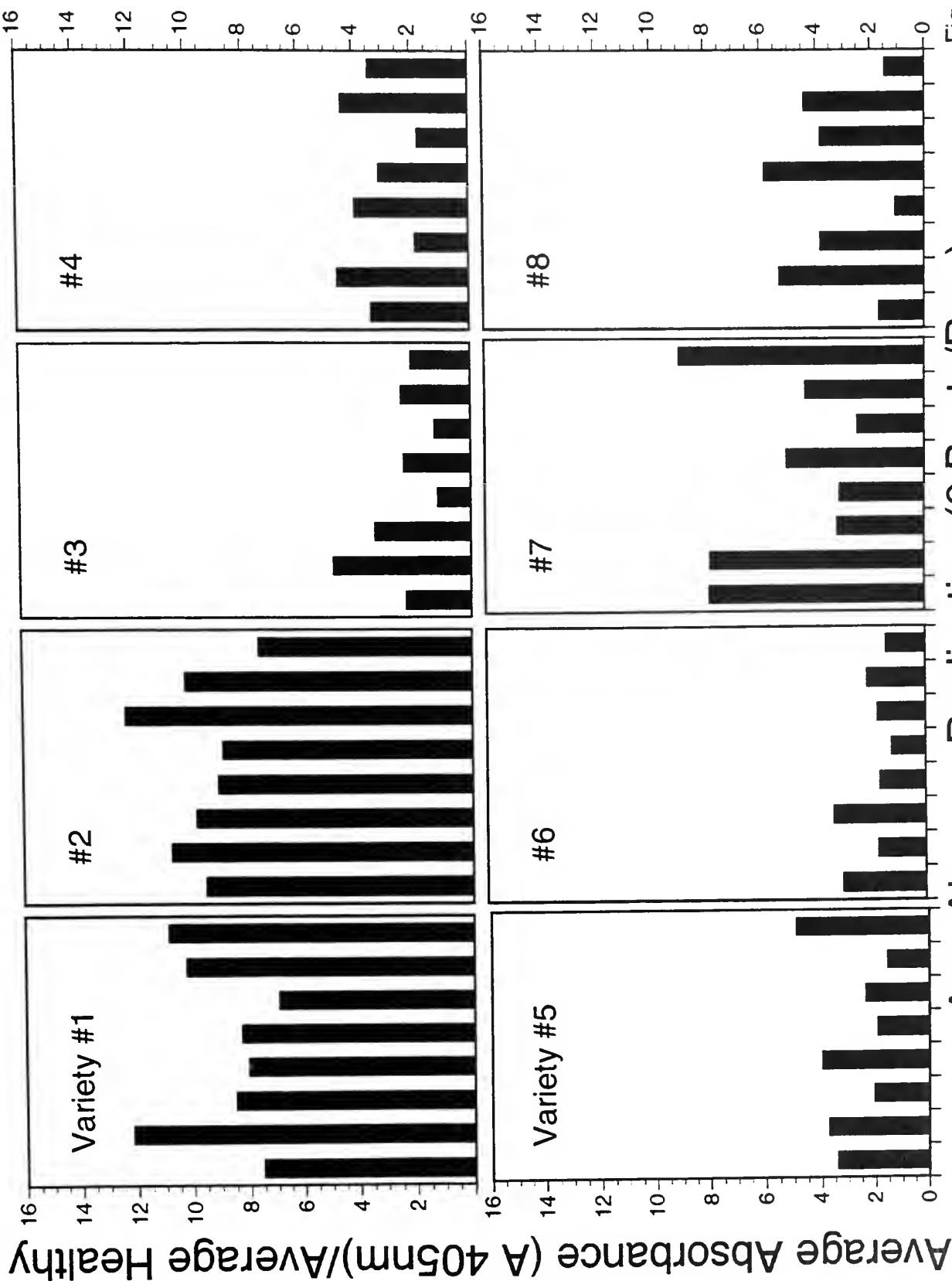


Fig. 1  
Ave. Abs. per Replication (9 Beets/Rep.)

TEST 4197. BYVV TITER (ELISA OD) OF SUGARBET HYBRIDS, SALINAS, CA., 1997

8 entries x 8 replications

Planted: May 1, 1997

3 harvest dates, split-plot; 1-row plots<sup>2</sup>

Harvested: 3 harvest dates<sup>1</sup>

Variety	Description		OD values <sup>5</sup>						OD/H <sup>6</sup>	
	Source	Area <sup>3</sup>	Resistance <sup>4</sup>	Date 1	Date 2	Date 3	Date 1	Date 2	Date 3	mean
<b>Susceptible checks</b>										
1 USH11	USDA	CA	rzzz	0.95	0.37	0.23	9.05	3.75	2.23	5.01a
2 KW6770	Betaseed	MN	rzzz	1.02	0.41	0.34	9.72	4.26	3.34	5.78a
<b>Resistant hybrids</b>										
3 Beta 4776R	Betaseed	CA	Rzzz	0.26	0.15	0.12	2.42	1.53	1.28	1.74c
4 SS-781R	Spreckels	CA	Rzzz	0.34	0.16	0.14	3.28	1.67	1.36	2.10c
5 Rival	Holly	CA	Rzzz	0.32	0.14	0.13	2.99	1.40	1.26	1.88c
6 HM7072	Novartis	MN	Rzzz	0.22	0.11	0.14	2.07	1.14	1.35	1.52c
7 Beta 4038R	Betaseed	MN	Rzzzzz	0.56	0.22	0.21	5.38	2.27	2.09	3.25b
<b>USDA exp. hybrid</b>										
8 6921H50	USDA	CA	Rzzz/Bvm bvm	0.36	0.19	0.16	3.41	1.96	1.53	2.30bc
Mean				0.50a <sup>9</sup>	0.22b	0.18b	4.79a	2.25b	1.81b	2.95
LSD (.05) (as RCB within each date) <sup>12</sup>				0.15	0.07	0.06	1.48	0.67	0.56	0.98
C.V. (%) (as RCB within each date) <sup>12</sup>				30.55	39.56	29.79	30.73	29.80	30.74	33.49
F value (variety)				63.88**	63.88**	63.88**	63.69**	63.69**	63.69**	63.69**
F value (date)				88.12**	88.12**	88.12**	78.43**	78.43**	78.43**	78.43**
F value (harvest date x variety) <sup>13</sup>				13.81**	13.81**	13.81**	12.83**	12.83**	12.83**	12.83**
LSD (.05) (variety for date x variety) <sup>13</sup>				0.10	0.10	0.10	0.98	0.98	0.98	0.98

<sup>13</sup> harvest dates: July 14 - 9 roots per plot (72 roots per variety) for individual root ELISA only; August 22 - 9 roots per plot (72 roots per variety) for individual root ELISA, root score (scale of 0 to 9), and root weight in grams; and, October 22 - 9 roots per plot (72 roots per variety) for individual root ELISA, root score, and root weight in grams with residual harvested for plot yield and % sucrose.

<sup>2</sup>Plots for Harvests 1 and 2 were 7.5 ft. long with 9 roots harvested randomly from each plot except end beets not used. Plots for Harvest 3 were 17 ft. long with two end beets skipped, the next 9 beets harvested individually for ELISA and the residual harvested in mass for root and sugar yield.

<sup>3</sup>Regional area that hybrid is grown or targeted. CA = California and Far West. MN = Minnesota, upper Midwest, and Eastern Slope.

<sup>4</sup>Probably genotype of most individual plants within hybrid. Some hybrids likely segregated for rzzz. Bvm = resistance from C51 (Beta vulgaris spp maritima) source. Rival may also have the Rizor source of resistance.

(cont.)

Variety	Root Scores <sup>7</sup>		Root Weight(g) <sup>7</sup>		Sugar Yield lbs/a	Root Yield t/a	Performance <sup>8</sup>	
	Date 2	Date 3	Date 2	Date 3			%	Beets/100' No.
<u>Susceptible checks</u>								
1 USH11	5.6	4.6	168.0	338.3	4737	24.04	9.80	178
2 KW6770	5.3	5.3	212.5	349.8	4639	20.67	11.29	167
<u>Resistant hybrids</u>								
3 Beta 4776R	2.9	2.1	293.3	765.6	12416	43.68	14.23	186
4 SS-781R	3.5	2.6	294.8	548.7	8322	31.89	13.03	166
5 Rival	2.2	2.5	303.1	515.5	9142	32.40	14.11	184
6 HM7072	4.1	3.1	294.9	613.9	8927	30.04	14.84	156
7 Beta4038R	4.1	3.4	253.6	605.9	11067	35.02	15.81	178
<u>USDA exp. hybrid</u>								
8 6921H50	3.4	2.8	323.8	720.3	10181	40.00	12.70	184
<u>Mean</u>								
LSD(.05) (as RCB) <sup>12</sup>	3.9a <sup>9</sup>	3.3b	268.0a	557.3b	8678.9	32.22	13.23	174.9
C.V. (%) (as RCB) <sup>12</sup>	1.3	0.9	54.0	139.1	1110.0	3.49	0.89	19.0
F value(variety)	33.3	26.7	20.1	24.8	12.7	10.77	6.72	10.8
F value (date)	15.6**	15.6**	14.6**	14.6**	50.8**	38.40**	38.81**	2.6*
F value (date x var)	8.9*	8.9*	183.2**	183.2**				
LSD(.05) (d x v) <sup>13</sup>	0.7NS	0.7NS	4.9**	4.9**				
	1.10	1.10	104.2	104.2				

<sup>5</sup>Values for 9 roots per plot averaged and used as plot data for ANOVA.<sup>6</sup>OD divided by OD for healthy root on same ELISA plate. Roots were randomly assigned to ELISA plates and positions.<sup>7</sup>Individual roots weighed and scored on a scale of 0 to 9 where 9 = severe rhizomania.<sup>8</sup>See Tests 1697, 1997, 3597, 3997 & 6097 for additional performance data on these 8 entries under rhizomania.<sup>9</sup>Date means with a letter in common are not significantly different (0.05).<sup>12</sup>LSD and C.V. for variety from RCB analyses within each harvest date.<sup>13</sup>LSD for date x variety interaction means.

TEST 4197. BYV TITER (ELISA OD) OF SUGARBEET HYBRIDS, SALINAS, CA., 1997

(cont.)

Variety	% Resistant (OD/H < 3) <sup>10</sup>			% Resistant (OD/H < 2) <sup>11</sup>		
	Date 1	Date 2	Date 3	Date 1	Date 2	Date 3
<u>Susceptible checks</u>						
1 US H11	6.94	47.22	79.17	4.17	20.83	63.89
2 KW6770	6.94	37.50	58.33	2.78	15.28	70.37
<u>Resistant hybrids</u>						
3 Beta 4776R	80.56	91.67	97.22	62.50	86.11	95.83
4 SS-781R	76.39	88.89	97.22	62.50	80.56	86.11
5 Rival	69.44	93.06	97.22	61.11	88.89	93.06
6 HM7072	83.33	98.61	95.83	76.39	98.61	91.67
7 B4038R	45.83	77.78	83.33	30.56	59.72	68.06
<u>USDA exp. hybrid</u>						
8 6921H50	70.83	80.56	91.67	38.89	76.39	79.17
Mean	55.03	76.91	87.50	42.36	65.80	81.02
LSD (.05)	18.44	18.44	18.44	20.72	20.72	20.72
C.V. (%)	14.39	14.39	14.39	18.76	18.76	18.76
F value	13.37**	13.37**	13.37**	11.82**	11.82**	11.82**

<sup>10</sup>% roots with OD/H less than 3.0

<sup>11</sup>% roots with OD/H less than 2.0

TEST 4197. COEFFICIENTS OF CORRELATION FOR PLOT VALUES (n = 64).  
Harvest Date 2 values are above the diagonal; Harvest Date 3 values are below.

	OD	OD/H	Score	Wt (g)
OD	---	1.00**	0.60**	-0.69**
OD/H	0.99**	---	0.60**	-0.68**
Score	0.69**	0.67	---	-0.46**
Wt (g)	-0.49**	-0.46**	-0.49**	---

# **SUGARBEET RESEARCH**

## **1997 REPORT**

### **Section B**

**U.S. Department of Agriculture, Agricultural Research Service  
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Dr. Susan S. Martin, Plant Physiologist**

### **Cooperation:**

**Colorado Agricultural Experiment Station**

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**Much of this research was supported in part by funds provided through the  
Beet Sugar Development Foundation  
(Projects 440, 441, 442, 443, 903, and 904)**

### **USDA-ARS-NPA Sugarbeet Research Unit's Mission Statement**

**Utilize distinctive site environmental and disease-free characteristics and specifically developed team expertise to: develop new knowledge and adapt biotechnologies to modify host-pathogen relations that affect disease resistance, pathogenesis, and epidemiology in sugarbeet and other plant species pertinent to sugarbeet cultivation; discover new information and techniques to identify and produce genotypes exhibiting superior disease and stress tolerance and agronomic qualities; and provide new knowledge that improves production efficiency and biochemical processing characteristics of sugarbeet.**



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## **USDA-ARS -NPA COLORADO-WYOMING RESEARCH COUNCIL**

**The Sugarbeet Research Unit** is a part of the Colorado-Wyoming (CO-WY) Research Council. This Council was chartered to promote and coordinate cooperative research activities among CO-WY Council research units; and facilitate communication and interaction with the Northern Plains Director, and among research programs and units and with customers locally, regionally, nationally and internationally. The five research units listed below publish an annual compilation of research reports. Many of the units are considering or have placed these reports on individual home pages which can be accessed through the NPA home page at [www.npa.ars.usda.gov](http://www.npa.ars.usda.gov).

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### **Rangeland Resource Research Unit (RRRU) - Cheyenne, WY, Fort Collins, CO & Nunn, CO**

**MISSION STATEMENT:** The mission of the Rangelands Resources Research Unit is to develop an understanding of the interrelationships of the basic resources that comprise rangeland ecosystems. Research is directed toward the development of science and technology that contributes to enhanced forage and livestock production and sustainable, productive rangelands in the Central Great Plains.

### **Central Plains Resources Management Research Unit (CPRMRU)- Akron CO.**

**MISSION STATEMENT:** To enhance the economic and environmental well-being of agriculture by development of integrated cropping systems and technologies for maximum utilization of soil and water resources. Emphasis is on efficient use of plant nutrients, pesticides, and water and soil conservation/preservation.

### **Great Plains Systems Research Unit (GPSRU) - Fort Collins, CO.**

**MISSION STATEMENT:** Help develop and implement sustainable and adaptive agricultural systems by: (1) synthesizing, quantifying, evaluating, and enhancing knowledge of processes; (2) developing integrated models of agricultural systems; (3) providing technology packages to agricultural communities and action agencies.

### **Soil-Plant-Nutrient Research Unit (SPNRU) - Fort Collins, CO.**

**MISSION STATEMENT:** To develop and evaluate new knowledge required to efficiently manage soil, fertilizer and plant nutrients (emphasis on nitrogen) to achieve optimum crop yields, maximize farm profitability, maintain environmental quality and sustain long-term productivity.

### **Water Management Resources Unit (WMRU) - Fort Collins, CO.**

**MISSION STATEMENT:** Research emphasis is to integrate applied and basic principles to develop improved water, chemical, and alternative weed management systems and irrigation system designs. Improvements are directed toward sustainable, environmentally sound and efficient systems based on soil, water, fertility, energy, and weed ecology principles. This encompasses understanding physical and biological phenomena and developing computer simulation models and precision farming systems to transfer new technologies to producers, consultants, action agencies, industry, and scientists.

For a copy of the Colorado-Wyoming (CO-WY) Research Council Annual Report or information on any of these programs, please note the following contacts:

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**PUBLICATIONS**  
**ABSTRACTS & GERMPLASM REGISTRATIONS**

Panella, L. Screening and utilizing *Beta* genetic resources with resistance to *Rhizoctonia* root rot and *Cercospora* leaf spot in a sugar beet breeding program. *In*: Frese, L., Panella, L., Srivastava, H.M., Lange, W. and S. Padulosi, editors. International Beta Genetic Resources Network. A report on the 4th International Beta Genetic Resources Workshop and World Beta Network Conference, February 28 - March 03, 1996. International Crop Network Series No. , International Plant Genetic Resources Institute, Rome. 1998. (In press).

\*Panella, L., J. Nishio, and Martin, S.S. The effect of foliar methanol application on sugarbeet yield. *In* Proceedings of the 60<sup>th</sup> Congress of the International Institute for Beet Research. Cambridge, England 29 June - July, 1997. p. (Poster)

\*Panella, L. and X. Yu. Use of nonradioactively-labeled sugarbeet probes to detect RFLPs. *In* Proceedings of the 60<sup>th</sup> Congress of the International Institute for Beet Research. Cambridge, England 29 June - July, 1997. p. (Poster)

\*Panella, L. Measuring Beta Genetic Diversity with Molecular Tools - Managing the information. Proceedings of the Plant and Animal Genome VI Meeting. 1998. (Abstract)

Panella, L. and E.G. Ruppel. Registration of sugarbeet germplasms FC721 and FC721CMS resistant to *Rhizoctonia* root rot and moderately resistant to the beet curly top virus. *Crop Sci.* 37(5):1675-1676. 1997.

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\*Abstract is included on the following pages.

## The Effect of Foliar Methanol Application on Sugarbeet Yield

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### ABSTRACT

Recently, researchers reported increased biomass production in agronomic and horticultural plants with foliar applications of methanol. Additionally, an increased water-use efficiency was reported in some crops when methanol was sprayed during times of water stress. An increase in the aboveground biomass of sugarbeet may lead to increased production of sucrose or an increased rate of physiological development in the beet root. Another benefit would be a decrease in the amount of irrigation water needed to produce the beet crop. A field trial was set up to examine three effects and their potential interaction. Three sugarbeet cultivars received three methanol treatments at 14 d intervals throughout the growing season: control (no spray); sprayed with a solution of 50% methanol plus 0.1% Triton X-100; and sprayed with a solution of 50% methanol, 0.2% monosodium glutamate (MSG), and 0.1% Triton X-100. Plots were sampled for weight of beets, sucrose as percent of root fresh weight (measured by polarimetry), and calculated sucrose yield (weight times % sucrose). Twice during the season, replicated gas exchange analyses were made on a subset of the field plots to measure photosynthesis. An analysis of variance (ANOVA) was performed on root weight, % sucrose, and sucrose yield. Gas exchange measurements showed an increase in photosynthesis for those water-stressed plots sprayed with methanol. Methanol treatments caused statistically significant decreases in weight, sucrose, and sucrose yield. A stimulation of photosynthesis normally results in an increase in biomass. For this to be economically beneficial in sugarbeet, the increase must occur in root weight or root sucrose percent, and an increase in one of these must occur without a compensatory decrease in the other. In this trial, although at least short-term increases in photosynthesis were measured in methanol-treated plants, both root weight and root sucrose percent decreased under methanol treatment. It is possible that increased photosynthesis resulted in an increase in above-ground growth at the expense of root growth and root sucrose storage. Such an effect often is seen when sugarbeet growth is stimulated by application of fertilizer late in the growing season.

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### Use of Nonradioactively-Labeled Sugarbeet Probes to Detect RFLPs

L. PANELLA<sup>1</sup> AND XIAOLI YU<sup>2</sup>

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<sup>2</sup>Department of Biology, Colorado State University, Fort Collins, CO 80523, U.S.A.

### ABSTRACT

Radioactive isotopes are increasingly difficult to dispose of, expensive to use, and, if used improperly, can present a health risk to researchers using them. There also are some distinct advantages in using

probes that are not labeled with radioisotopes to detect molecules at low concentrations. Techniques relying on nonradioactive isotopes have advantages of a much longer shelf-life of the labeled probe. We have used probes that had been labeled 1 year previously and noticed no loss of activity. Nonradioactive isotopes often can be detected much more quickly. During the first probing of a membrane, the labeled-probe often is detected after 15 to 30 minutes exposure to X-ray film. The biggest drawback to nonradioactive isotopes has been that a single membrane cannot be stripped of probe and reused as often as when radioisotope-labeled probes are used. However, when a membrane is to be used only a limited number of times, i.e., for genetic-distance studies or diagnostic tests, this is not a problem. We report a protocol to directly PCR-label DNA probes with digoxigenin-dUTP, to hybridize those probes to enzyme-restricted sugarbeet genomic DNA, and to detect those probes with a chemiluminescent reaction. In our laboratory, a positively charged nylon membrane from Boehringer Mannheim™ performed best. Digoxigenin-labeled DNA probes were able to detect single copy sugarbeet sequence in as little as 645 ng of genomic DNA, with an exposure time of 15 to 30 minutes for the first probing. Stripping of the membrane and re-probing was optimized to provide sensitivity at the fifth probing comparable to the first probing, with a small increase in background hybridization. We were able to detect polymorphisms among and within sugarbeet accessions using these techniques.

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### Measuring *Beta* Genetic Diversity With Molecular Tools - Managing The Information Lee Panella

It is estimated that there are about 10,000 accessions in *Beta* genetic resources collections around the world. Each genebank has the same mission, which can be divided into seven parts: 1) Collection, 2) documentation, 3) characterization, 4) evaluation, 5) regeneration, 6) distribution, and, finally, 7) utilization. We expect that molecular markers and other tools based on the rapid advances in molecular biology, will have a large impact on most of these genebank functions. That this already is happening is evidenced by the topics that will be discussed at this Sugar Beet Workshop. We will hear about molecular characterizations of *Beta* taxonomy and cytogenetics, as well as discrimination at the sugar beet variety level. Efforts to understand the basic genetic control of monogermity, resistance to leaf spot and the beet cyst nematode, and bolting will be discussed. As the pace of this research increases, I think that it is important that we researchers start to think about, and plan for, the management of the this information. It is easy to say, simply, that it will go into databases, because it will. How these databases are constructed, accessed, and linked, however, will determine how useful this information will be. There are some things than can be done easily to allow for comparison across experiments. One suggestion that I would put forth here is that a group of 'type accessions' be run with every genetic diversity study. This is a small number of accessions and will allow comparisons across experiments. They will be available at no cost from the U.S. National Plant Germplasm System (NPGS) and the Federal Centre for Breeding Research on Cultivated Plants (BAZ) Plant Genetic Resource Collection. Let us begin the dialogue now to plan and implement a system of information management that will allow easy access to a well-indexed system tied into our genetic resources databases.

## Notice of Release of FC709-2 and FC727 Multigerm Sugarbeet Germplasms.

Panella, L. and E. G. Ruppel.

United States Department of Agriculture, Agricultural Research Service; Washington, DC and  
Beet Sugar Development Foundation; Denver, Colorado.

The USDA Agricultural Research Service (ARS), in cooperation with the Beet Sugar Development Foundation (BSDF), announces the release of FC709-2 and FC727 multigerm sugarbeet germplasms. These lines should provide excellent resistance to root-rotting strains (AG-2-2) of *Rhizoctonia solani* Kühn and good to moderate resistance to Cercospora leaf spot caused by *Cercospora beticola* Sacc. They are potential pollinators, or populations from which to select pollinators with combining ability for yield. FC709-2 and FC727 are released from seed productions 9210124 and 951017, respectively.

FC709-2 is multigerm (*MM*), non O-type, pseudo self-fertile, and has 13% green hypocotyls. It is segregating with approximately 19% male sterility. Of 122 plants examined for pollen production, there were 8% Type 0, 11% Type 1 (both considered male sterile), 14% Type 2, and 67% Type 3. FC709-2 is the result of three cycles of selection within the most resistant population (871016) that went into FC 709. This population first was mass selected for resistance to *Rhizoctonia* root rot caused by *R. solani*, and surviving roots were increased in bulk in a field isolation plot where they also were re-inoculated with *R. solani*. Twenty-eight plants were harvested. Seed was split and planted into a disease-free nursery and a nursery inoculated with *R. solani*. Fifty-three roots were selected from the disease-free nursery based on percent sucrose of individual roots (highest 9.4%), and these were increased in bulk with three roots selected for *Rhizoctonia* resistance. Seed was harvested from a total of 33 surviving. This population underwent another cycle of mass selection for resistance to *Rhizoctonia* root rot, and the 121 surviving roots were harvested in bulk to produce the seed released as FC709-2.

FC709-2 had excellent resistance to *Rhizoctonia* root rot when tested under strong disease pressure. There were either no significant differences or FC709-2 performed better than the *Rhizoctonia*-resistant controls in disease index (DI) ratings from 1994 through 1997, respectively (DI of 0 = no root rot and 7 = all plants dead). FC709-2 was always significantly better than the susceptible control (FC901/C817//413). FC709-2 had mean disease indices (DI's) of 1.0, 1.5, 0.9, and 2.5 (1994-1997), whereas the highly resistant control (FC705/1) had DI's of 1.4, 1.4, 1.5, and 3.2, respectively. Of all lines tested, FC 709-2 had the lowest DI in the very severe epiphytotic of 1997. Percentages of resistant plants (those rated 0 or 1) were 86, 55, 100, and 49 for FC709-2; and 65, 58, 62, and 49 for the highly resistant check.

FC709-2 also showed good resistance to *Cercospora* leaf spot when tested in an artificial epiphytotic. In tests from 1994, 1995, and 1997, it was significantly better than the susceptible control and not significantly different from the resistant control. The following DI ratings (DI of 0 = no leaf spot and 10 = all plants dead) are from the most severe rating (last of three or four ratings each season). The test from 1996 is excluded because, due to a non-uniform disease intensity, there were no significant differences among lines tested in that year. In 1994, 1995, and 1997, DIs of FC709-2 were 3.0, 4.3, and 4.17/3.5 (tested in two trials); DIs of the resistant control (FC504CMS/FC502-2//SP6322-0) were 3.2, 3.5, and 3.8/2.9; DIs of the susceptible control

(SP351069-0) were 4.5, 6.2, and 7.0/6.5, respectively. FC709-2 does not show tolerance to the curly top virus. As with the parent line, FC709, field testing of FC709-2 in California revealed a very low frequency of plants that exhibit some resistance to rhizomania (R. T. Lewellen, personal communication). This germplasm is, however, not recommended as a source for rhizomania resistance.

In a yield trial with some drought stress (unpublished data), the sucrose yield (root weight x percent sucrose) of FC709-2 was 89% of 'Beta 2398' and 66% of 'Monohikari', and the percent sucrose was 102% of 'Beta 2398' and 86% of 'Monohikari'. FC709-2 has not been tested for combining ability. It is released for use as a pollinator for making *Rhizoctonia* root rot- and *Cercospora* leaf spot-resistant hybrids, or as a source population from which such pollinators can be selected.

FC727 is multigerm (*MM*), non O-type, and has 51% green hypocotyls. FC727 resulted from the cross FC703 (50% of the genetic contribution) and three high sucrose sources - Polish AJ, -ZZ (16%), the Spanish line 'Aula Dei 13' (21%), and American Crystal's '67-436' (13%). The effective population size of the  $F_1$  was 92 plants. FC727 is the result of eight generations of mass selection for resistance to *Rhizoctonia* root rot induced by *R. solani* and four simultaneous generations of mass selection of individual roots for high sucrose. The smallest population size was 26 roots and, on average, the highest 18% of the roots were selected for sucrose.

FC727 has excellent resistance to *Rhizoctonia* root rot when tested under strong disease pressure. There were no significant differences between it and *Rhizoctonia* resistant controls in DI ratings, and FC727 tested significantly better than the susceptible control (FC901/C817//413) from 1994 through 1997. FC727 had mean disease indices (DI's) of 1.4, 1.7, 1.1, and 3.6 (1994-1997), while the highly resistant control (FC705/1) had DI's of 1.4, 1.4, 1.5, and 3.2, respectively. Percentages of resistant plants (those rated 0 or 1) were 69, 41, 89, and 16 for FC727; and 65, 58, 62, and 49 for the highly resistant check.

FC727 has some resistance to *Cercospora* leaf spot. When tested from 1994 through 1997 in an artificial epiphytotic of *Cercospora* leaf spot, it was significantly better than the susceptible control but, also, significantly worse than the resistant control. The following DI ratings are from the most severe rating (last of three or four ratings each season). The year 1996 is excluded because, due to a non-uniform disease intensity, there were no significant differences among lines tested. In 1994, 1995, and 1997, DI's of FC727 were 3.8, 4.5, and 4.8; DI's of the resistant control (FC504CMS/FC502-2//SP6322-0) were 3.2, 3.5, and 2.9; DI's of the susceptible control (SP351069-0) were 4.5, 6.2, and 6.5, respectively. FC727 does not show tolerance to the curly top virus.

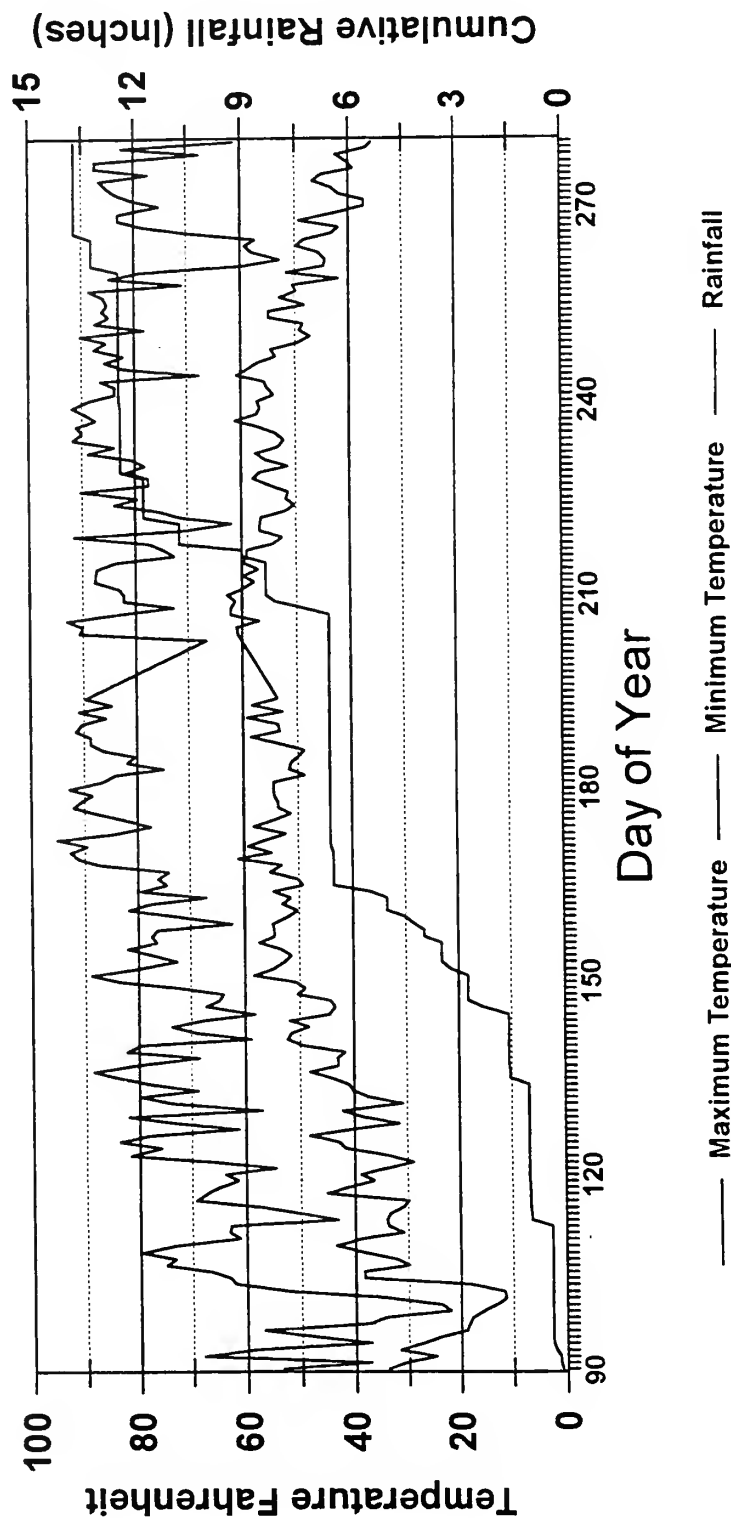
FC727 has relatively good general combining ability for sucrose yield when used as a pollinator on several diverse CMS lines (unpublished data). FC727 has potential for use as a pollinator or a population from which to choose pollinators with good combining ability. It should contribute to the synthesis of high sucrose hybrids with resistance to *Rhizoctonia* root rot.

Breeder seed of FC709-2 and FC727 is maintained by USDA-ARS and will be provided in quantities sufficient for reproduction upon written request to Sugarbeet Research, USDA-ARS, Crops Research Laboratory, 1701 Center Ave., Fort Collins, CO 80526-2083. Genetic material of this release will be deposited in the National Plant Germplasm System where it will be available for research purposes, including development and commercialization of new varieties/cultivars. We request that appropriate recognition be made of the source when this germplasm contributes to a new cultivar.

**Figure 1** Weather Data was received from Colorado's CoAgMet system, which is electronically reported, and can be accessed off of the Colorado Climate Center Website which can be reached at the following URL - <http://ulysses.atmos.colostate.edu/> The Lucerne weather station is located one quarter mile southwest of Lucerne, Colorado (Lat = 40.4753, Lon = 104.7075, elevation = 4750). Our Windsor plots are located about 10 miles west of Lucerne (about Latitude = 40.2730, Longitude = 104.5500, elevation = 4800). The *Cercospora* leaf spot nursery was planted on day 120 (May 1), inoculated on days 177 (June 27) and again on day 188 (July 8). Evaluations were made on days 244, 251, and 258 (September 2, 9, and 16). The *Rhizoctonia* root rot nursery was planted on day 127 (May 8), inoculated on day 190 (July 10) and evaluated on day 231 (August 20).

## 1997 Weather Summary

Lucerne Station near Windsor





# **RHIZOCTONIA ROOT ROT RESISTANCE AND DEVELOPMENT OF GENETIC RESISTANCE IN SUGARBEET - BSDF Project 440**

L. Panella and E. G. Ruppel (retired)

This facet of the USDA-ARS Fort Collin's sugarbeet breeding program has as its goals: 1) the understanding the genetics of the *Rhizoctonia solani*/sugarbeet interaction in order to better facilitate development of germplasm with high levels of resistance to Rhizoctonia and other sugarbeet diseases, and 2) to provide the knowledge to better manage this disease in sugarbeet production areas. It is an integrated research program with greenhouse, laboratory, and field components. Genetic information developed previously in our research is used to execute additional cycles of pathogen inoculation, plant selection, and recombination among germplasms that we have in our cyclic improvement program. Germplasms in various stages of improvement are evaluated for resistance in inoculated field tests. Results of these tests form the basis of decisions about specific germplasm, i.e., retain, shelve, discard, recombine, release, etc. Germplasms likely to be useful for variety improvement are identified and released for use by other sugarbeet breeders.

## **1997 Field Research on Rhizoctonia Root Rot of Sugarbeet.**

The breeding program in Fort Collins has created annually an artificial epiphytotic through inoculation with *Rhizoctonia solani* for over thirty years to evaluate and select for resistance to root rot caused by this pathogen. We have been pleased to participate and lead this cooperative research project between the ARS, Colorado State University, and the BSDF. The project primarily involved field studies conducted on 35 acres of leased land near Windsor, CO. Randomized, complete-block designs with five replicates were used to evaluate Fort Collins ARS breeding germplasm. *Rhizoctonia*-resistant line FC703 and highly susceptible FC901/C817//413 were included as internal controls, along with highly resistant FC705-1. One-row plots, planted in mid-May, were 4.3 m (14 feet) long with 56 cm (22 inches) between rows and 20- to 25-cm (8-10 inches) within-row spacing. Fertilization was based on soil test recommendation. The field was sprayed 12 days after planting (dap) with Betamix Progress (1.25 pint/acre) and Upbeet (0.75 oz./acre) and again 22 dap with Betamix Progress (1.25 pint/acre), Upbeet (0.75 oz./acre), and Stinger (0.25 pint/acre). Any additional weed control was by hand hoeing and the plots were thinned to 8 in spacing between beets starting about 6 wk after planting.

Stand counts were made on all plots the week before inoculation and inoculation with dry, ground, barley-grain inoculum ( $3.0 \text{ g m}^{-1}$ ) of *Rhizoctonia solani* isolate R-9 was performed on July 10<sup>th</sup>. Immediately after inoculation, a cultivation was performed to throw soil into the beet crowns. Beets were harvested on August 20<sup>th</sup> and 21<sup>st</sup>. Each root was rated for rot on a scale of 0 to 7 (no rot to dead), and plot means for disease index were calculated. Analyses of variance (PROC ANOVA - SAS) were performed on disease indices (DIs), percent healthy roots (classes 0 and 1 combined), and percentage of roots in classes 0 thru 3 (those most likely to be harvested and taken to the factory). Percentages were transformed to arcsin-square roots to normalize the data for analyses ("Z hlthy" and "Z 0-3" in Table 1). Both percentages and arcsin transformations are given in Table 1. LSDs ( $P = 0.05$ ) are provided for comparing DIs and arcsin transformations among entries and with our internal checks.

### **Allotment of Fort Collins "FC" numbers (3-digit numbers)**

"FC" numbers are "convenience" numbers for "seed releases" or purposes where a permanent line designation is needed — i.e. a number that does not change from generation to generation where little or no selection pressure is applied. Initially, an "FC" no. was written thus "FC 501" [now FC727], "FC 502 CMS" [now FC715CMS], etc. Sublines (from selfing) were designated thus, "FC 502/2" [now FC709-2], "FC502/3" [now FC502-3], etc. The same applies when the line is substantially changed by selection without selfing.

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Below 500	Originally LeRoy Powers - now parental lines and special genetic stocks.
500's	Leaf Spot Resistant (LSR), Type-O lines & male steriles [CMS]
600's	LSR-Curly Top Resistant (CTR), type-O lines & male steriles [CMS]
700's	Rhizoctonia Resistant
800's	LSR-CTR-Rhizoctonia resistant
900's	Pollinators, LSR-CTR type

Ample rainfall early in the season, followed by protracted high temperatures and more heavy rain in July and August (Figure 1), led to an extremely severe root rot epidemic in our 1997 nursery. Differences in DIs among entries in all tests were highly significant ( $P < 0.0001$ ). Mean DIs in this test for the highly resistant, resistant, and highly susceptible controls were 3.2, 3.5, and 6.6, respectively. In a normal year, the resistant controls have a DI between 1 and 2, and the susceptible check has a DI between 5 and 6.

### **Transforming Rhizoctonia-Resistant Populations to Germplasm with Multiple Disease Resistance**

Root rot and leaf spot are two serious diseases of sugarbeets caused by fungi (*Rhizoctonia solani* and *Cercospora beticola*, respectively). The diseases caused by these fungi may produce a severe reduction of yield in many sugarbeet production areas. Cultural control measures are not adequate by themselves, and often no chemicals are registered for control of these diseases, or chemical control is expensive or environmentally unsafe. Increased levels of genetic resistance in sugarbeet varieties are needed to minimize growers' losses from these diseases. In a hybrid crop like sugarbeets, it is preferable that all of the parents contain some level of resistance to diseases prevalent in the area in which the hybrid is to be grown. Multiple disease resistance is a difficult goal in a crop improvement program, especially when working with an outcrossing species. In alternating generations of selection, some of the progress made in resistance to one disease is lost while selecting for resistance to other diseases.

One way of solving the problem of selecting for multiple disease resistance is the use of progeny testing. By testing the progeny of individual mother roots, plants with multiple disease resistance can

be identified and used as parents of the next generation. The most efficient use of progeny testing is when the genotype of both parents is controlled, and the most effective way to do this is through self-pollination. In sugarbeet, there is a dominant, self-fertility gene that permits self-pollination. Used in conjunction with genetic male sterility, to insure cross pollination, a system of selfed-family progeny testing can be utilized.

This effort is based on the *Rhizoctonia*-resistant materials from the programs of John Gaskill and Richard Hecker, and disease resistant germplasm from other sources to produce germplasm highly resistant to *Rhizoctonia solani*. This base of *Rhizoctonia*-resistant germplasm is being combined with material from the USDA-ARS breeding programs at Salinas and Fargo, as well as with sources for higher yield and sucrose. The Salinas material has the self-fertility allele, is segregating for genetic male sterility, and also contains a broad spectrum of resistance to diseases of importance in California as well as other sugarbeet production areas (including rhizomania, powdery mildew, virus yellows, and curly top virus). Fargo sources of root maggot and *Cercospora* leaf spot resistance are also being utilized.

A number of source populations are being developed. The germplasms, FC709-2 and FC727, were released in 1998. The germplasms were developed in our research project that has been contributed to, in kind, by the Beet Sugar Development Foundation. The newly released germplasms combine excellent *Rhizoctonia*-root-rot resistance with a good level of leaf spot resistance. (See the release notice following the abstracts above.) Germplasms whose development was begun under the breeding program of Dr. Richard Hecker are still being evaluated in the field. Twelve of these germplasms and other germplasms from the Fort Collins program were field-tested in 1997 summer for resistance to *R. solani*, *C. beticola*, and the curly top virus (Tables 1-3).

At least two more germplasms showing outstanding performance in 1997 field trials will be released in 1998. More germplasms that were selected for increased resistance to *Rhizoctonia*-root-rot in 1996, and tested in 1997, will be tested again in 1998; and the most promising of these will be released in the future.

Other source populations also are being developed. A monogerm population, segregating for *Rhizoctonia*-root-rot and other disease resistances, self-fertility, and genetic male sterility, was derived from bulked seed from the crosses 2890 (sp)/FC708 and 2859 m (sp)/FC708. Individual F<sub>2</sub> mother roots from the 1995 field were selfed, and the selfed families tested in the 1996 BSDF Curly Top Nursery. Remnant seed was grown in the greenhouse and bulk-increased seed was used to plant the 1997 *Rhizoctonia* nursery. Bulk-increased seed from selections made in the 1997 *Rhizoctonia* nursery will be tested in Salinas for rhizomania resistance and in the Fort Collins *Rhizoctonia* Root Rot Nursery.

A multigerm population consists of the cross, FC709-2 x 2915 (sp) RZM, and its reciprocal. This population was bulk increased in the greenhouse in 1997. Half-sib from these plants will be progeny tested in 1998 for resistance to *Rhizoctonia* and Curly Top. Selected families will be recombined and further improved.

Seed of selections for *Rhizoctonia* resistance within FC907, a multigerm, leaf spot resistant

germplasm, are being tested in this year's Rhizoctonia Nursery. FC907 is a cross between FC701 and FC607, which was backcrossed four times to the leaf spot resistant parent (FC607). It has been shown to have excellent *Cercospora* leaf spot resistance in the last three years of testing, and is being released from the USDA-ARS breeding program in Fargo. Selections were made in the 1996 Rhizoctonia nursery and bulk-increased in isolation in 1997.

### **Genetic Relationships among Isolates of *Rhizoctonia Solani* and Variation in Pathogenicity to Sugarbeet**

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USDA Agricultural Research Service <sup>1</sup> Sugarbeet Research Unit, Fort Collins, CO

<sup>2</sup>Plant Genetic Resources Conservation Unit, Griffin, GA.

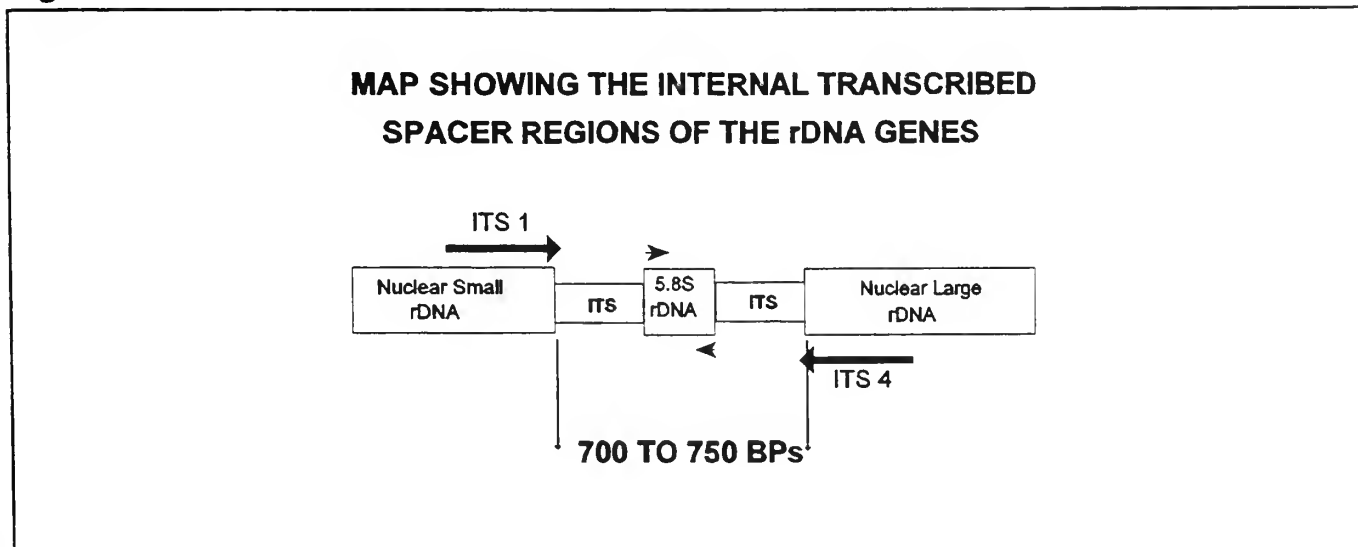
Currently, it is possible to assay the pathogenicity to sugarbeet of an isolate of *R. solani* through a greenhouse bioassay only, which may take 12 to 16 weeks. Although there has been recent work done on the phylogenetics of this pathogen, evolutionary relationships among isolates have not been well correlated with the host specificity of the fungus. Whether the pathogenicity to sugarbeet has evolved once or more than once in this fungus could substantially influence its interaction(s) with the sugarbeet plant.

*R. solani* is divided into anastomosis groups (AGs) based on the ability of the hyphae to fuse and exchange genetic material, and into subgroups based on morphological, physiological, or, more recently, biochemical and molecular markers. The internal transcribed spacer (ITS) sequences flanking the 5.8S ribosomal RNA gene (rDNA) (Figure 2) have been used for this purpose and, in general, for phylogenetic studies because they are extremely variable within species.

Isolates of *R. solani* from AG-4 cause seedling damping-off in sugarbeet, and isolates from AG-2 cause root and crown rot in mature beets. AG-2 is divided into subgroups AG-2-1 and AG-2-2 based on frequency of anastomosis and thiamine auxotrophy (AG-2-2), and AG-2-2, which is pathogenic to sugarbeets, is further divided into subgroups IIIB or IV based on growth at 35°C. In this country, we have found both AG-2-2 IIIB and AG-2-2 IV to be pathogenic on sugarbeet but group IIIB to be the most virulent.

The polymerase Chain Reaction (PCR) was used to amplify the DNA of 92 isolates of *R. solani* coding for the 5.8S ribosomal RNA gene (rDNA) as well as the two flanking ITS regions. This was done with the ITS1 and ITS4 primers (Figure 2) (Lee & Taylor, 1990). Restriction enzymes that recognize four base-pair sites (*AluI*, *HaeIII*, *HhaI*, *HinfI*, *HpaI*, *RsaI*) were used to create restriction fragment length polymorphisms (RFLPs) from the amplified DNA fragments. There were also, in some cases, initial differences in the size of the amplified length of DNA, which varied from approximately 700 to 750 base pairs. The DNA was separated on agarose gels, visualized with ethidium bromide, and photographed. The enlarged photographs were used to estimate the fragment sizes, by comparison with markers of known size (from a *HaeIII* digest of  $\Phi$ X174RFI). Each isolate was scored for the presence/absence of all possible RFLPs generated by each restriction enzyme (5 to 10 RFLPs each). These data were analyzed and a phylogenetic tree was generated from this information. This tree

Figure 2.



did discriminate between AG-2-2 isolates and other AGs but did not give adequate discrimination within AG-2-2 or among the other AGs.

Isozyme markers from four enzyme systems ( $\alpha$ - Acid phosphatase [ $\alpha$ -ACP], Phosphoglucumutase (PGM), Glucose-6-Phosphate-dehydrogenase (G6PDH), and Malate dehydrogenase (MDH)) are being used to further discriminate among isolates.

In collaboration with the USDA-ARS Plant Introduction Station at Griffin, GA, we have sequenced the DNA of the two ITS regions as well as the 5.8S rDNA gene from 70 isolates of *R. solani*. This was done with a PCR reaction using the ITS-1 and ITS-4 primers, as well as primers on either side of the 5.8S rDNA gene (Figure 2). These sequence data, with the isozyme data, will allow us to characterize the genetic diversity among *Rhizoctonia* isolates. These data have been used to determine the phylogenetic relationships among different isolates of *R. solani*.

We also have been testing the *Rhizoctonia* isolates for their pathogenicity to sugarbeet. The *R. solani* isolates have been tested for their virulence to sugarbeet seedlings. The Chi-square values (difference between the untreated control and the reaction of two sugarbeet lines to each isolate) have been used to classify the isolates based on their pathogenicity. These isolates then were tested in the greenhouse for pathogenicity on 10-wk-old sugarbeet roots (one resistant and one susceptible line). The test was a randomized complete block design with six replicates. Results of the greenhouse screening will be correlated with the phylogenetic relationships determined from the sequence data to see if all the isolates pathogenic to sugarbeet belong in the same genetic grouping.

This is a project that has been under ways since 1994 and is being completed this year. Final data have been analyzed and the manuscript is being prepared for publication. We are now working with the sequence data to see if it is possible to develop a quick molecular means to identify those isolates which are pathogenic to sugarbeet. We are looking for short, unique sequences within the ITS regions that can be used to "fingerprint" isolates of *R. solani* that are pathogenic on sugarbeet.

**Table 1. 1997 Rhizoctonia Nursery (4R) at Fort Collins, CO.**

Seed Source	Designation	Description	DI <sup>1</sup>	% Hlthy <sup>2</sup>	% 0 - 3 <sup>-3</sup>	Z% <sup>4</sup> Hlthy	Z% 0 - 3
			LSD <sup>5</sup>	1.2		15.5	19.5
921024	FC709-2	+2 cycles Rhizoc&1 cyclesucose	2.5	49.3	79.9	44.3	66.2
921022	FC702-7	+7 cycles of Rhizoc selection	2.5	28.1	76.8	31.3	65.0
931009	FC710(4X)	FC710 colchicine doubled	2.7	20.7	81.0	26.8	67.5
921021	FC703-5	+5 cycles Rhizoc	2.8	29.0	75.4	32.0	61.8
931013	FC712(4X)	FC712 colchicinedoubled	2.9	28.5	72.3	31.0	61.9
881032H	FC712	Fort Collins Release	3.1	25.4	64.0	27.3	53.3
961014	FC724	FC702/LSR-CTR	3.2	19.0	65.0	24.9	54.8
<b>831083</b>	<b>FC705/1</b>	<b>Highly Resistant Check</b>	<b>3.2</b>	<b>48.8</b>	<b>63.9</b>	<b>44.8</b>	<b>54.3</b>
921019	FC729	FC712/A4,3 cycles Rhizoc, MM	3.4	25.8	60.6	29.9	51.3
<b>751080H</b>	<b>FC703</b>	<b>Resistant Check</b>	<b>3.5</b>	<b>16.1</b>	<b>55.3</b>	<b>23.2</b>	<b>51.3</b>
941038		FC701/LSR-CTR)O-type, mm	3.6	15.2	64.6	20.6	57.3
951017	FC727	FC703/(AJ-ZZ&AulaDei&67-436),MM	3.6	15.8	53.0	20.8	46.8
961010HO	FC722	C718/FC708	3.7	26.2	56.4	24.4	48.8
961015	FC720	C718/(C718/FC708)	3.7	20.8	56.2	25.2	49.4
961011HO		FC607/FC708	4.1	15.2	48.9	17.8	44.1
931005HO	FC721	Syn(FC701/LSR-CTR)//C718, mm	4.3	27.9	41.7	25.8	38.6
931005HO1	FC721CMS	C718CMS//Syn(FC701/LSR-CTR), CMS	4.4	11.4	39.9	15.0	35.9
961012HO1		FC712/Mono-HyA4	4.5	11.7	43.7	14.7	40.9
961011HO1		FC607/FC708	4.8	2.9	17.7	4.4	23.6
97J21-2		East Lansing - Joe Saunders	4.9	12.9	32.0	18.9	33.5
961012HO		FC712/Mono-HyA4	5.1	4.3	31.2	5.5	30.0
96A009	EL 50	East Lansing Release	5.3	2.2	27.6	3.9	31.0
97J21-3		East Lansing - Joe Saunders	5.5	8.3	24.5	10.5	25.6
97J21-1		East Lansing - Joe Saunders	5.5	9.6	21.5	13.4	25.7
SR87	SR87	East Lansing - Joe Saunders	5.7	7.3	12.6	13.7	19.5
97J21-4		East Lansing - Joe Saunders	5.7	0.0	17.2	0.0	21.0
961010HO1	FC722CMS	C718/FC708	6.1	3.1	10.2	4.6	14.5

Table 1. 1997 Rhizoctonia Nursery (4R) at Fort Collins, CO.

Seed Source	Designation	Description	DI <sup>1</sup>	% Hlthy <sup>2</sup>	% 0 - 3 <sup>-3</sup>	Z% <sup>4</sup>	Hlthy	Z% 0 - 3
			LSD <sup>5</sup>				15.5	19.5
97A004	EL 48	East Lansing Release	6.1	2.9	6.6	4.4	11.6	
USH20	US H20	East Lansing - JohnHolloin	6.3	2.1	3.2	5.3	8.1	
951035	FC714	Synthetic from (701/mmO-Type)aa/mmO-Type LSR-CTR	6.4	2.9	9.1	4.4	11.3	
Beta 5931	Beta 5931	East Lansing - JohnHolloin	6.5	0.0	1.7	0.0	4.7	
<b>931017</b>		<b>Susceptible Check - (FC901/C817)//413</b>	<b>6.6</b>	<b>1.5</b>	<b>2.9</b>	<b>3.2</b>	<b>6.2</b>	
E-17	HM E17	East Lansing - John Holloin	6.7	0.8	3.0	2.4	7.7	

<sup>1</sup>Disease Index is based on a scale of 0 (=healthy) to 7 (= plant dead).

<sup>2</sup>Percent of healthy roots (disease classes 0 and 1 combined).

<sup>3</sup>Percent of diseased roots likely to be taken for processing (disease classes 0 through 3 combined).

<sup>4</sup>Percentages were transformed to arcsin-square roots to normalize the data for analyzes.

<sup>5</sup> $\alpha=0.05$ .

## **CERCOSPORA LEAF SPOT RESEARCH AND BREEDING FOR CERCOSPORA AND CURLY TOP RESISTANCE - (BSDF Project 441)**

L. Panella<sup>1</sup>, E. G. Ruppel<sup>1</sup> (retired), and G.A Smith<sup>2</sup>.

USDA-ARS <sup>1</sup>Fort Collins, CO and <sup>2</sup>Fargo, ND

This element of the breeding program at Fort Collins is devoted to the development of germplasm with resistance to more than one sugarbeet disease and improved agronomic characteristics. It is built on germplasm developed at Fort Collins over the last fifty years for combined resistance to *Cercospora* leaf spot and the curly top virus. This is an integrated breeding program with greenhouse and laboratory studies, and a field program based on testing in an artificial epiphytotic created in the unique Fort Collins environment. It involves close collaboration with the other USDA-ARS sugarbeet programs in the U.S. and sugarbeet seed industry customers. The major goals of this program are: 1) the development of sugarbeet germplasm with resistance to more than one disease and excellent agronomic characteristics; 2) the improvement of breeding techniques, traditional and molecular, to develop this germplasm; and 3) an increased understanding of the sugarbeet/pathogen interactions to improve management practices of these diseases in sugarbeet production areas. Genetic information developed during this research will be used to execute additional cycles of pathogen inoculation, plant selection, and recombination among germplasms that we have in our leaf spot improvement program. Results of these tests will be the basis of decisions about specific germplasm, i.e., retain, discard, recombine, release, etc. Germplasms likely to be useful for variety improvement will be identified and released for use by other sugarbeet breeders.

Increased resistance to *Cercospora* continues to be an extremely important goal. If the level of resistance available in most *Cercospora*-resistant experimental lines were present in commercial hybrids (along with good sugar and seed yield), the need for fungicides would be greatly reduced. That continued improvement in genetic resistance to this serious pathogen is still needed is evident by the occurrence of *Cercospora* strains that are resistant or increasingly tolerant to our most potent fungicides. Additionally, some of these fungicides may be removed from the market because of their perceived or real threat to the environment. In many areas where *Cercospora* leaf spot is a problem, the curly top virus also causes significant losses. And, there are some growing areas in which combined resistance to *Cercospora* leaf spot, *Rhizomania*, curly top, *Rhizoctonia* root rot, and other diseases are desirable. Germplasm is needed with combined resistance to these diseases, along with good combining ability for yield components.

### **1997 Field Research on Cercospora Leaf Spot of Sugarbeet**

The breeding program in Fort Collins has created an artificial epiphytotic through inoculation with *Cercospora beticola* annually for over forty years to evaluate and select for resistance to leaf spot caused by this pathogen. We have been pleased to participate and lead this cooperative research project between the ARS, Colorado State University, and the BSDF. The project primarily involved field studies conducted on 35 acres of leased land near Windsor, CO.

Randomized complete-block designs, with three replications were used to evaluate breeding germplasm. Internal controls included a highly susceptible synthetic and a resistant check, FC(504 X 502/2) X SP6322-0. Two-row plots were 4 m (12 feet) long, with long with 56 cm (22 inches) between rows and 20- to 25-cm (8-10 inches) within-row spacing. The nursery was planted on May



1<sup>st</sup>. Fertilization was 75% of the soil test recommendation to minimize leaf growth, which can interfere with visual evaluations. The field was sprayed 14 days after planting (dap) with Betamix Progress (1.25 pint/acre) and Upbeet (0.75 oz./acre) and again 26 dap with Betamix Progress (1.25 pint/acre), Upbeet (0.75 oz./acre), and Stinger (0.25 pint/acre). Any additional weed control was by hand hoeing, and the plots were thinned to 8 inch spacing between beets starting 5 wk after planting.

The *Cercospora* nursery was inoculated twice, on June 27<sup>th</sup> and July 8<sup>th</sup>. Visual evaluations on a scale from 0 (no disease) to 10 (plant dead) were made on September 2<sup>nd</sup>, 9<sup>th</sup>, and 16<sup>th</sup>, with the peak of the epidemic occurring on or about the last date. The 1997 leaf spot epidemic progressed rather slowly at first, but rapidly became quite severe by late August to early September due to high humidity and temperature (Figure 1). At our third evaluation, means of the resistant and susceptible internal controls were 3.7 and 7.3, respectively, across all trials in the nursery. An analysis of variance (PROC ANOVA - SAS) on the disease indices (visual evaluation scores) determined that there were significant differences among entries ( $P=0.05$ ) on all three dates (Table 2).

### **Cercospora/Curly Top-Resistant Populations with Resistance to Multiple Sugarbeet Diseases and Superior Agronomic Characteristics**

Advanced breeding lines or *Cercospora*-resistant germplasms from Fargo (7), Salinas (13), East Lansing (11), and Fort Collins (10) were evaluated in Experiment 8A at the ARS leaf spot nursery at Ft. Collins (Table 2). Thirty-five Fort Collins advanced breeding lines or released germplasms were evaluated for *Cercospora* leaf spot resistance (Table 8) and curly top resistance (Table 3) in a joint project with the Institute for Sugarbeet Breeding in Croatia. FC907, a multigerm, leaf spot resistant germplasm, is being increased and should be released from Fargo this coming year. This is a cross between FC701 and FC607, which was backcrossed four times to the leaf spot resistant parent (FC607). It has been shown to have excellent *Cercospora* leaf spot resistance in the last three years of testing.

This *Cercospora* leaf spot-resistant, multigerm parent developed in Fargo (FC907), has been crossed with FC709-2, a *Rhizoctonia* and *Cercospora* resistant multigerm pollinator germplasm from Fort Collins (See the release notice in the Abstracts sections above). This population will be a source of self-incompatible lines with excellent root rot and leaf spot resistance. This  $F_2$  population was selected in the *Rhizoctonia* nursery last year and was bulk-increased in the greenhouse this winter. It will be tested in both *Rhizoctonia* and *Cercospora* nurseries this summer. It has also been crossed with a high sucrose population and a population with curly top resistance. Seed from these populations will be reselected for resistance to leaf spot, root rot, and curly top as well as agronomic performance.

The  $F_1$  hybrid of FC907 x FC709-2 was crossed in the greenhouse in Fargo with root maggot resistant germplasm. The resulting population  $F_2$  is being grown out in Fargo and will be selected to produce plants that have combined resistance to leaf spot, root rot, and root maggot.

A population from which to choose multigerm pollinators highly resistant to *Cercospora*, with good combining ability for agronomic traits is being developed. A cross among a highly *Cercospora*-resistant line (FC607 - ♀), a smooth root line from the USDA-ARS sugarbeet research group in East Lansing (SR87 - ♂), and commercial diploid hybrids developed by the defunct Great Western

program (MonoHy A4, MonoHy T6, and MonoHy T7 - ♂'s), forms the basis of this population. Individual mother roots ( $F_2$ ) will be selfed in Masonville, CO, this summer, taking advantage of pseudo self-fertility; and the selfed seed used to progeny test for resistance to *Cercospora* leaf spot. This population will be recombined and selected for both agronomic performance and increased leaf spot resistance.

Two populations have been created combining the base *Cercospora* resistant germplasm from Fort Collins with germplasm from the USDA-ARS breeding program at Salinas, CA. The first population is a monogerm population ([2890aa & 2589aa x FC607 & FC604] and the reciprocal), segregating for *Cercospora* leaf spot, Rhizomania, other disease resistances, self-fertility, and genetic male sterility. It should provide a source of monogerm, O-type lines.

Selfed progeny ( $S_1$ ) rows of this monogerm population, 971011 & 971012ms, were selected in the Fort Collins leaf spot nursery and BSDF curly top nursery in 1996; and the best performing lines in this nursery were bulk-increased (971011 and 971012ms) and tested in 1997 (Tables 2 & 3). These lines were also grown in Salinas and selections were made for resistance to Rhizomania (Table 4). Mother roots from these lines are being random mated in the greenhouse and half-sib selections will be made this summer in the *Cercospora* and curly top nurseries. These selections will be recombined with selections from the Rhizomania nursery in Salinas.

A multigerm source population, originating from the cross (4918aa/R278/FC902), is segregating for *Cercospora* leaf spot, Rhizomania resistance, other disease resistances, and self-fertility. The combination of Salinas and Fort Collins germplasm should provide a source of multigerm pollinators with combined leaf spot, curly top, and Rhizomania resistance. This population ( $F_2$  plants) was increased in bulk and crossed to *Cercospora*-resistant selections from the multigerm populations derived from FC907 x FC709-2, and the polycross with FC607 to produce populations from which multigerm pollinator germplasm with resistance to *Cercospora*, Rhizomania, and curly top can be selected.

The seed from the above mentioned populations will be developed and advanced after testing. Development of a resistant germplasm line generally takes 7 years. A longer time may be necessary to incorporate multiple disease resistances. In an established program, a "pipeline" of lines in various stages of development and evaluation is the norm. Hence, the release of new germplasm usually occurs every 2 to 4 years.

Genetic information developed in this research will be used to execute additional cycles of pathogen inoculation, plant selection, and recombination among germplasms that we have in our leaf spot improvement program. Results of these tests will be the basis of decisions about specific germplasm, i.e., retain, discard, recombine, release, etc. Germplasms likely to be useful for variety improvement are identified and released for use by other sugarbeet breeders. Breeding techniques are compared in developing these germplasm and information on the efficacy and efficiency of these techniques generated.

**Table 2. Experiment 8A, 1997. Leaf Spot Evaluation of USDA-ARS Fort Collins, Salinas, East Lansing, and Fargo breeding lines.**

Source		Variety and/or description	Disease Index <sup>1</sup>		
			Sept 2	Sept 9	Sept 16
		LSD ( <i>P</i> = 0.05)	0.7	0.9	1.0
931002		LSS=syntheticcheck <sup>2</sup>	5.50	7.00	7.00
821051H2		LSR <sup>3</sup>	2.67	3.00	3.83
86A0010	SP85590-0	Ex. LSR, mod AphanR, reasonable sucrose - CMS	3.00	3.00	4.00
79A067		FC607	2.67	3.33	4.17
921024		FC709-2 + 2 cycles Rhizoc & 1 cycle sucrose	2.33	3.00	4.17
86A009	SP85590-01	Ex. LSR, mod AphanR, reasonable sucrose - O-type	2.83	3.50	4.17
941038		FC701xLSR/CTR	2.83	3.50	4.17
78A044		FC606	2.67	3.33	4.50
971011		LSR selections from 961007-Xs (eq. amounts w/ 971013)	2.83	3.50	4.67
941018HO1		FC607CMS	2.67	3.67	5.00
971012ms		CTRselectionsfrom961007-Xs	4.33	5.50	6.67
971010		LSS selections from 961007-Xs	4.17	6.00	6.83
R609R2		Salinas - CR-RZM R409R2	3.17	4.00	5.33
R609		Salinas - CR-RZM R409 (CR09)	3.33	4.17	5.33
R626		Salinas - RZM R526 [(F3(C37 x Bmu-UK Pla)]	3.33	4.83	5.67
R610R2		Salinas - CR-RZM R610R2	3.67	4.67	5.83
R681		Salinas - NB-RZM Re81-#s,... (C82)	4.67	5.67	6.00
R639		Salinas - RZM R539 (C39R)	4.00	5.17	6.17
R610		Salinas - CR-RZM R410 (CR10)	3.50	4.83	6.17
R678(Iso)		Salinas - NB-RZM R478NB (C78)	4.50	6.17	6.50
R522		Salinas - C51	4.50	6.33	6.67
R722		Salinas - RS 1987 (C50)	4.33	5.50	6.67
6931		Salinas - 5915, ... aa x A (MM, Sf, Aa, Rz popn)	4.17	6.17	7.00
R680NB		Salinas - NB-RZM R480NB (C80NB)	5.33	6.17	7.00
6869		Salinas - 5869mmaa x A (mmpopn)	4.83	6.67	7.00
96A009	EL50	East Lansing release with LSR, AphanR, & RhzcR	2.83	3.17	3.83
97J21-2		East Lansing	3.00	3.17	4.17
SR87		East Lansing	2.50	3.33	4.33
WC960448		East Lansing	3.33	3.83	4.67
97J21-4		East Lansing	3.00	3.33	4.83
WC960452		East Lansing	3.17	3.33	4.83
96HS12-01		East Lansing	3.17	3.83	4.83
97A004	EL48	East Lansing release with LSR, AphanR, & RhzcR	3.17	3.50	4.83
SR93		East Lansing	3.17	3.83	5.00
96HS3-01		East Lansing	3.33	4.33	6.00
96HS20-7		East Lansing	3.83	4.67	6.00
962002		Fargo - increase of 922022H2 rouged to green	2.83	3.50	4.67
962006		Fargo - increase of 942003H2	3.00	3.17	5.00

**Table 2. Experiment 8A, 1997. Leaf Spot Evaluation of USDA-ARS Fort Collins, Salinas, East Lansing, and Fargo breeding lines.**

Source	Variety and/or description	Disease Index <sup>1</sup>		
		Sept 2	Sept 9	Sept 16
	LSD ( $P = 0.05$ )	0.7	0.9	1.0
931002	LSS=syntheticcheck <sup>2</sup>	5.50	7.00	7.00
821051H2	LSR <sup>3</sup>	2.67	3.00	3.83
942001	Fargo - FC907	3.00	3.83	5.17
962005	Fargo - increase of 942002H2	2.83	3.50	5.50
962001	Fargo - increase of 922021H2 rouged to green	3.67	5.00	5.50
962003	Fargo - increase of 922023H2 rouged to green	4.00	5.33	5.67
962004	Fargo - increase of 942024H2	3.50	4.17	6.00

<sup>1</sup>Disease Index is based on a scale of 0 (=healthy) to 10 (=dead).

<sup>2</sup>The Leafspot Susceptible Check is SP351069-0.

<sup>3</sup>The Leafspot Resistant Check is FC 504CMS/FC 502-2//SP6322-0.

**Table 3. Curly Top Evaluation of USDA-ARS Fort Collins Breeding Lines - 1997  
Bsdf Curly Top Nursery in Kimberley, ID.**

Source	Variety and/or Description	Disease Index <sup>1</sup>	
		Aug 25	Sept 11
	LSD ( $P=0.05$ )	0.85	0.85
94A068	Beta G6040 - Resistant Check	3.2	4.2
951016HO	FC723 - EL44/FC708, mm	3.2	4.3
911042HO1	FC402CMS - released	3.2	4.3
911043HO1	FC403CMS -	3.5	4.5
86A047	FC607CMS (4x ) - released	3.7	4.7
86A046	FC606 (4x) - released	3.8	4.7
86A048	FC607 (4x) - released	3.7	4.8
781035HO	FC606	4.2	4.8
961011HO1	FC607/FC708	4.0	5.0
961011HO	FC607/FC708	3.8	5.0
971012ms	CTR selections from 961007-Xs	3.3	5.2
86A045	FC606CMS (4x ) - released	4.8	5.2
86A006	SP 8541-0	4.0	5.2
971011*	*LSR selections from 961007-Xs (eq. amounts w/ 971013)	4.0	5.2
97A004	EL 48 - East Lansing release	4.3	5.3
911043HO	FC403 - released	3.5	5.3
911026HO	FC715 - released	4.0	5.3
911042HO	FC402 - released	3.8	5.3

**Table 3. Curly Top Evaluation of USDA-ARS Fort Collins Breeding Lines - 1997  
Bsd Curly Top Nursery in Kimberley, ID.**

Source	Variety and/or Description	LSD(P=0.05)	Disease Index <sup>1</sup>	
			Aug 25	Sept 11
<b>94A068</b>	<b>Beta G6040 - Resistant Check</b>		<b>3.2</b>	<b>4.2</b>
951016HO1	FC723CMS - EL44CMS/FC708, CMS		3.8	5.5
971015	RhczMM pop		4.2	5.5
931005HO	FC721 - Syn (FC701/LSR-CTR)//C718, mm		3.8	5.7
971010	LSS selections from 961007-Xs		4.2	5.7
781035HO1	FC606CMS		4.5	5.8
931005HO1	FC721CMS - C718CMS//Syn (FC701/LSR-CTR), CMS		4.3	5.8
921022	FC702-7 + 7 cycles Rhizoc		4.5	6.0
921025	FC728 - (A4 & D2 & 309)/FC708, MM		4.0	6.0
961010HO	FC722 - C718/FC708		4.3	6.0
731028HO	FC902		4.7	6.0
79A067	FC607 - released		4.8	6.0
86A005	SP 8540-0		4.7	6.2
86A004	SP 8531-0		4.8	6.2
86A007	SP 85576-01		4.7	6.2
921021	FC703-5 + 5 cycles Rhizoc		4.8	6.3
891037	AD2 (4x)		4.7	6.3
951017	FC727 - FC703/(AJ-ZZ & Aula Dei & 67-436), MM		4.7	6.3
86A008	SP 85576-0		4.8	6.3
86A011	SP 85655-01		5.5	6.5
771067HO	FC504		5.5	6.5
86A012	SP 85655-0		5.2	6.5
961015	FC720 - C718/(C718/FC708)		4.7	6.5
911031	FC717 - released		5.0	6.7
86A014	SP 85657-01		5.2	6.7
96A009	EL 50 - East Lansing release		4.8	6.7
86A013	SP 85657-0		5.7	6.8
831085HO	FC708 - released		5.2	6.8
86A015	SP 85700-0		4.8	6.8
961014	FC724 - FC702/LSR-CTR		5.0	6.8
961010HO1	FC722CMS - C718/FC708		5.3	7.0
86A001	SP 85303-0		5.5	7.0
921024	FC709-2 + 2 cycles Rhizoc & 1 cycle sucrose		5.5	7.0
86A003	SP 85320-0		5.3	7.2
831028HO	FC506		5.5	7.2
911032	FC718 - Susceptible Check		5.7	7.3
86A010	SP 85590-0 Ex. LSR, mod AphanR, reasonable sucrose		5.5	7.5
86A002	SP 85320-01		6.2	7.7

<sup>1</sup>Disease Index is based on a scale of 0 (=healthy) to 10 (=dead).

**Table 4. 1997 Rhizomania Nursery - Salinas, CA (R. T. Lewellen - Data are from Test 5697).**

Designation	Description	Acre Yield		Beets/		RJAP <sup>2</sup>	Powdery		Rhizomania
		Sugar	Beets	Sucrose	100'		Mildew <sup>1</sup>	Score	
US H11	113102, 3-8-7	1928	10.95	8.75	186	72.7	4.6	5.3	23.4
R609R2	CR_RZM R409R2. (CR09)	5425	22.80	11.85	181	77.0	5.3	3.3	76.9
LSR	971011 & 971013 - Fort Collins	3877	19.66	9.85	180	78.1	3.3	4.2	49.3
CTR	971012ms - Fort Collins	4550	18.89	12.05	190	74.0	5.6	4.5	41.1
Mean		4486.1	18.89	11.84	179.4	76.9	5.1	3.7	62.3
LSD (0.05)		942.5	3.45	1.10	18.9	4.1	0.8	0.5	13.2
C.V. (%)		21.3	18.53	9.41	10.7	5.4	15.4	12.7	21.5
F value		6.7**	6.04**	5.91**	3.3**	1.4 NS	5.1**	8.4**	7.6**

<sup>1</sup>Powdery Mildew Score is based on a scale of 0 (=healthy) to 9 (=dead).

<sup>2</sup>RJAP = Raw juice apparent purity.

## GENETIC DIVERSITY PRESENT IN CULTIVATED AND WILD *BETA* GERMPLASM (BSDF Project 442)

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### Discussion of the Problem

The amount of genetic diversity in a population depends on many factors. A few factors include: inbreeding, plant reproductive system, environment, diversity in founding population, time that population has been in existence, and gene immigration. Within a hybrid parent, less diversity means a more uniform hybrid; however, the more genetic diversity between the hybrid parents, the greater the heterosis seen in the resultant hybrid. The amount of diversity present in a wild population determines the number of individuals that need to be sampled in each population and the total number of populations that ought to be sampled to adequately represent the genetic diversity contained in those populations. It also indicates the population size that needs to be grown out to maintain the total genetic diversity originally present in a population.

The relationship between two inbreds, lines, or populations can be defined in terms of genetic distance. Knowledge of genetic distances among genotypes within germplasm sources is critical for the continued success of plant breeding programs. Conservation methods for crop germplasm may also be affected by genetic relationships among commercial and breeding lines. Although pedigree information and taxonomic studies provide useful information for plant breeders interested in questions of genetic diversity, the ability to utilize DNA technology, such as molecular markers, provides a more accurate and reliable glimpse into these genetic relationships.

We recently have conducted several investigations in our laboratories to better understand the genetic relationships among beet breeding lines, open-pollinated populations, and hybrids. These investigations have demonstrated substantial genetic variation among and within populations in beet genotypes. For example, the Madison laboratory screened 12 individuals from each of 45 open-pollinated lines of red beet with a series of RAPD primers to assess genetic distance among and within lines. Analysis of these data is currently in progress; however, preliminary findings suggest substantial variability within populations. This, in turn, suggests that preservation and utilization of some of our more variable open-pollinated populations may represent large amounts of the genetic diversity in cultivated genotypes. In addition, these studies have afforded the opportunity to examine genetic relationships across different pools of cultivated germplasm. Although data analysis is not complete, clustering of various line types is apparent, indicating genetic distance estimates among these genotypes will reveal useful information for future breeding efforts.

This information can in turn be used to plan crosses and, perhaps, maximize genetic diversity and heterosis. Moreover, molecular markers have been used to assess the relationship among species in the genus *Beta*, providing a clearer phylogenetic picture of this group of plants. **Sugarbeet breeders would benefit from knowledge of the genetic relationships in all of the germplasm pools that are easily accessible through traditional hybridization techniques.** At present, little information regarding genetic distance among cultivated sugarbeet genotypes has been conducted. The objective of this investigation is to assess genetic distance within and among cultivated breeding lines and wild accessions of *Beta*.

**OBJECTIVE:** The objective of this investigation is to assess genetic distance within and among cultivated sugarbeet breeding lines and other cultivated and wild *Beta* accessions within section Beta to provide necessary information to sugarbeet breeders and *Beta* curators using this germplasm.

### **Final Report to BSDF on Research Progress - 1997**

M. Wang and I.L. Goldman - University of Wisconsin-Department of Horticulture

To begin the initial phase of this project, we chose a hybrid cultivar and an inbred line of red beet to use as source material for DNA analysis. We were initially interested in (1) choosing PCR primers for subsequent DNA analysis; and (2) working out some of the statistical analyses we would need for analysis of these data. Thus, the report below outlines our description of the general procedure for obtaining and analyzing these kinds of data. In addition to this report, we have isolated DNA from individual plant samples (ca. 50 plants) from each of three populations: Hybrid, Inbred Line, and Open-Pollinated Cultivar. These DNAs will be used to direct PCR amplification according to the information below as well as be shared with Dr. Lee Panella for RFLP analysis.

**Plant Germplasm** - DNA was extracted from individual plants of the F1 Hybrid cultivar 'Red Ace' and the inbred line 'W425B.' The inbred line W425B was developed by W.H. Gabelman at the University of Wisconsin-Madison and the hybrid Red Ace is derived from inbreds developed previously at the University of Wisconsin-Madison. DNA was isolated according to the PEX method previously described by Skroch and Nienhuis (1995). For this preliminary screening, six individual DNA samples were chosen and analyzed for a number of primer combinations.

**Primer Selection** - Thirty 10-base pair primers from Operon Technologies (Alameda, CA) were chosen for initial PCR amplification of DNA samples. Twenty-one primers were selected based on the consistency and clarity of polymorphic bands. These primers included AA03, AA10, AA12, AA14, AB01, AB09, AB11, AB17, AB18, AC07, AC15, AC19, AC20, AD02, AE07, AE08, AE09, AF11, AF14, AI04, and AI17.

**Polymerase Chain Reaction Amplification** - Reactions were run in 96-well Falcon assay plates according to standard protocols. Each reaction contained 5 µl of DNA dilution (containing 5-10 ng of DNA), 12.8 µl of water, 2.5 µl of 10x buffer, 1.5 µl of 10 mM MgCl<sub>2</sub>, 1.0 µl of 10 mM primer, 2.0 µl total of 1.25 mM each dNTP's and 0.2 µl of TAQ polymerase (2-5 units/µl). Two drops of mineral oil were added to assay plate wells to minimize evaporation. Controls containing no template DNA were added to each reaction plate. Amplification conditions were 1 minute at 94°C, 5 seconds at 94°C, 6 cycles of 30 seconds at 92°C, 1 minute at 36°C, 1 minute at 72°C and 36 cycles of 30 seconds at 92°C, 1 minute at 36°C and 1 minute at 72°C. Amplification reactions ran for 42 cycles in a MJ Research PTC-100 Programmable Thermal Controller. Amplification products were electrophoresed on 2% low EEO agarose gels. Bands were visualized via ethidium bromide staining. A 100 base pair ladder was used as a molecular weight standard on each gel. Amplification products in the form of fluorescent bands resulting from each primer-DNA combination were scored on a presence-absence basis. Scored amplification products were generally in the range of 275-2000 base pairs. Amplification reactions yielded from 1-10 discreet, scorable amplification products. Amplification products were designated by primer name followed by molecular weight.



**Genetic Distance Calculations** - In order to determine the genetic relationships among the DNA samples amplified, we attempted a preliminary genetic distance calculation. The genetic distance (GD) matrix was completed using a program written in the C programming language provided by Paul Skroch of the University of Wisconsin-Madison. Estimates of GD were calculated for all 96 individual samples based on the complement of the simple matching coefficient. The matrix of GD value was analyzed by unweighted classical multidimensional scaling (MDS). Variance analysis for GD estimates was performed using the analysis of molecular variance and an F-test was performed to determine significance among the population samples. We assumed a genetic model with a single locus and two alleles for each polymorphic band. Marker diversity was calculated as Nei's gene diversity at a locus.

**Mean Genetic Distance Estimates** - The W425B DNA samples exhibited a mean genetic distance of 0.315 and the Red Ace DNA samples exhibited a mean genetic distance of 0.314. These were not significantly different using an LSD value at the 0.05 level (equivalent to a genetic distance of 0.008).

**Mean Molecular Variance for Genetic Distance** - No significant differences were detected within the population of DNA samples for W425B (0.007) or for Red Ace (0.001), suggesting a high degree of genetic homogeneity within the cultivar or inbred line tested.

**Average Gene Diversity** - Nei's gene diversity was calculated as 0.029 for W425B and 0.021 for Red Ace. These are much lower estimates of gene diversity than have been detected for sugar beet breeding lines in previous investigations by our group. In some cases, these estimates are one order of magnitude less than for other *Beta vulgaris* breeding populations.

**Conclusions** - The procedures developed for RAPD analysis and statistical analysis of RAPD-generated data should be sufficient for comparison within and among the Beta accessions for the proposed project.

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L. Panella - USDA-ARS-NPA Sugarbeet Research Unit

In choosing the initial material for this study we wanted a cross-pollinated (i.e. self-incompatible) population and a more inbred line. FC703 was chosen as the population. It is a cross between FC701 and FC702, which are the first two *Rhizoctonia* resistant releases selected out of the Great Western open pollinated varieties. As an inbred, 52-305CMS was chosen. This is the CMS female from one of "Demming's Inbreds", which is in the  $S_{12}$ .

**DNA Extraction** - DNA has been isolated from 76 individual plants of FC703 and 83 individual plants of 52-305CMS. This was done with a slight modification of the method of Gepts et al. (1992). DNA was digested with *EcoRV* and *HindIII*, and a Southern transfer of 8  $\mu$ g of DNA per lane was bound to nitro cellulase membranes.

**Detection of RFLPs** - Eighteen RFLP probes and four mini-satellite probes have been labeled with digoxigenin, which is used in conjunction with the Genius® System for DNA hybridization and RFLP detection. This labeling method has been used with a chemiluminescent detection system and optimized for use with sugarbeet DNA. Results presented are from RFLPs detected using this

method. These are very preliminary results which have not been subjected to peer-review and should be treated as such.

**Table 5. Preliminary look at distribution of RFLPs in two sugarbeet populations.**

Sugarbeet Germplasm	Percent of the Population with Detected Fragment				
	Probe 510/ <i>EcoRV</i>		Probe 1159/ <i>EcoRV</i>		
FC703	49	49	3	96	24
52-305CMS	72	81	70	70	42
Fragment size (bp)	6800	6200	8300	5300	4200

Data from 2 more probe/enzyme combinations currently are being collected and analyzed.

### Future Plans

The extracted DNA will be evaluated at both locations and then samples exchanged. These samples will then be evaluated at both Fort Collins and Madison. Data then will be analyzed and genetic variation within and between populations calculated.

### Short Summary of Literature

Nienhuis and colleagues outlined the uses of molecular markers in assessing genetic relationships among genotypes. These workers concluded that the usefulness of these markers is promoted by their (1) large numbers, (2) lack of environmental interaction, and (3) ability to be organized into linkage groups. In a number of cases, estimates of genetic relationships determined through marker-based distance calculations have correlated well with plant performance and pedigree. Dos Santos and co-workers recently determined that both RAPDs and RFLPs are useful tools for discriminating among genetic relationships in *Brassica oleraceae*. These workers concluded that little difference in genetic distance estimation between these marker systems was found. In general, recent research has revealed both marker systems give reliable and repeatable estimates of genetic distance among groups of commercial lines, populations, and breeding lines.

Distance measures with molecular markers generally are based on a presence/minus basis. With two inbreds, four types of matches between the inbreds are possible: presence of the band in both inbreds (1-1), presence of a band in one inbred but not in the other (1-0 and 0-1), and absence of the band in both inbreds (0-0). Matrices developed from these data may be analyzed with a number of different distance measures, including those summarized by Dudley: the simple matching coefficient, Nei and Li's coefficient, Gower's coefficient, and Rogers' distance. Each of these methods has been used successfully to measure genetic distance among cultivated accessions of crop plants.

The development of RAPD technology has increased the efficiency of evaluating marker linked regions of the genome. RAPD markers, which are generated as a result of polymerase chain reaction-based amplification of genomic inverted repeats, are extremely useful in development of highly-saturated genetic linkage maps in many plant and animal species. Results of recent

investigations in sugarbeet revealed substantial amounts of random amplified sequence polymorphism with a small number of random sequences among cultivated genetic materials. This finding suggests the likelihood of detecting sufficient random amplified sequence variation in sugarbeet for identification of useful RAPD marker loci in this investigation. Eagen and Goldman have demonstrated the utility of RAPD technology in assessing marker frequency changes across cycles of recurrent selection in red beet. In addition to these findings, these workers have identified a number of RAPD primers that amplify beet DNA with clarity and accuracy. It is the aim of the Madison program to use these markers in the proposed study.

RFLP Markers exhibit varying degrees of efficacy for detecting differences among taxa within the genus *Beta*. These markers have been used to create a saturated linkage maps of the sugarbeet genome: (1) using F<sub>2</sub> progeny from an intraspecific cross within the sugarbeet genepool and (2) based on an F<sub>1</sub> X F<sub>1</sub> intraspecific population. Another, more recent, study by Hjerdin and colleagues examined cross hybridization of probes using different stringencies in the hybridization protocol. These researchers calculated an index of variation based on the probability that two accessions, randomly chosen from a group, would have different phenotypes for a particular probe. These studies all indicate the usefulness of some RFLP markers within the sugarbeet genepool and of many markers between *Beta vulgaris* and other species within and outside of the section *Beta*. RFLP markers received from Drs. Jung & Steinrücken in Germany are being used in the program at Fort Collins. They mark each chromosome arm of the sugarbeet genome in the linkage map produced by Pillen and co-workers. These RFLP markers will be used in this study.

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## PRE-BREEDING: THE INTROGRESSION OF NEW SOURCES OF CERCOSPORA LEAF SPOT RESISTANCE FROM *BETA VULGARIS* SPP. *MARITIMA* AND OTHER EXOTIC SOURCES INTO SUGARBEET-TYPE POPULATIONS. (BSDF Project 443)

L. Panella

A major emphasis of the research mission of the USDA-ARS plant scientists is the collection, documentation, characterization, evaluation, regeneration (maintenance), distribution, and utilization of plant germplasm, especially Plant Introduction (PI) accessions in the USDA-ARS National Plant Germplasm System (NPGS). The Sugarbeet Research Unit at Fort Collins is coordinating the national program for *Beta* germplasm evaluation. In addition to the evaluation for Rhizoctonia and Cercospora resistance, it is crucial that the ARS scientist be involved in the long range, high risk research problems involved in sugarbeet 'germplasm enhancement' or 'pre-breeding'. This is an important component in the overall sugarbeet improvement effort of the Fort Collins Sugarbeet Research Unit.

**Justification for Research:** Cercospora leaf spot (caused by the fungus *Cercospora beticola* Sacc.) is one of the most widespread diseases of sugarbeet and is a serious problem in many sugarbeet production areas throughout the U.S. The disease damages the leaves, which, consequently, reduces root yield, percent sucrose of roots, and purity of the extracted juice. Cercospora leaf spot currently is controlled by combining spraying with commercial fungicides and the use of disease tolerant germplasm. The development of Cercospora leaf spot resistant sugarbeet lines and hybrids with greater levels of host-plant resistance offers a more sustainable solution to this disease problem.

If the level of resistance available in some *Cercospora*-resistant experimental breeding lines were present in commercial hybrids (**along with good sugar and seed yield**), the need for fungicides could be greatly reduced. That continued improvement in genetic resistance to this serious pathogen is still needed is evident by the occurrence of *Cercospora* strains that are tolerant to our most potent fungicides. Additionally, some fungicides may be removed from the market because of their perceived or real threat to the environment.

Finally, the genepool for resistance to Cercospora leaf spot is extremely narrow. Many of the resistant lines are highly inbred, therefore, closely related to one another, and stem from germplasm coming out of Italy in the early 1900s. In the germplasm developed at Fort Collins, continued inbreeding has increased the level of disease resistance, but at the cost of plant vigor. Over the long term, a secure, sustainable response to this disease requires commercial quality hybrids with good host-plant resistance.

### Objectives:

1. The formation of long range breeding populations through the introgression of Cercospora resistant germplasm from "exotic" sources (*Beta vulgaris* spp. *maritima*, fodder beet, foreign sugarbeet landraces from the PI collection, etc.).
2. The development of germplasm populations from these long range populations that are of sufficient agronomic quality to be of use to commercial breeders. They will be a source of leaf spot resistance with differing genetic backgrounds.

3. The development of techniques (both traditional and molecular) to more efficiently introgress the exotic germplasm into sugarbeet breeding populations.

**Research Progress 1997:** Ten crosses have been made in the greenhouse and the seed harvested. These three sources of *Cercospora* leaf spot resistance (LSR) both biennial and annual. They were crossed to genetic male sterile (*aa*) sugarbeet females within a population segregation for this trait. These sources of LSR include PI 535826 (fodderbeet from Poland) and both annual and biennial *B. vulgaris* subsp. *maritima* from France and Greece. Of the ten crosses there are insufficient seed in three to proceed further - they will be repeated.

Sugarbeet parents are currently in induction and will be used to cross to five more annual *B. vulgaris* subsp. *maritima* that have been identified as LSR. These crosses should be completed by the fall of 1998. There are few more sources of resistance that are being considered to cross.

Seed from the first crosses will be planted in May, induced, and random mated this coming season. All will be cycled through at least three cycles of random mating prior to selection. Development of a resistant germplasm line generally takes seven years. A longer time will be necessary to incorporate disease resistance from more exotic sources. Because this is a new program it will take time for the first germplasm to make it through the process. Once that happens, there will be a "pipeline" of germplasm in various stages of development and the release of new germplasm will occur every two to four years. The incorporation of exotic sources into agronomically acceptable germplasm is a long term proposition - results will not appear overnight. This is the type of long-term, high risk germplasm research that ARS is well-suited to perform.

**Materials and Methods:** Artificial inoculation with *Cercospora beticola* and leaf spot scoring will be used to identify the resistant germplasm sources and make selections in the developing populations. The exotic materials will be crossed into sugarbeet populations that have been selected for agronomic quality (recoverable sucrose yield). These are currently under development using germplasm received from commercial breeding programs, public sources (e.g., L19), and some high sucrose germplasm from Poland. These sugarbeet populations will be self-fertile (*S*<sup>f</sup>) and segregating for nuclear male sterility (*A-:aa*). Populations will be handled in the following manner: 1) Following the initial cross, a population will be random mated (using *aa* females because of the self-fertility) for three to four generations to break up linkage groups and remove annual plants. 2) Sugarbeet-type mother roots will be selected, selfed, and progeny tested for agronomic performance and disease resistance. 3) Selected roots will be recombined (and backcrossed if desirable) and re-selected until they ready for release. Molecular markers (RFLPs, RAPDs, SSRs, AFLPs, etc.) will be used to expedite the backcrossing program and to follow the change in allele frequencies in the selected populations. Advanced populations will be released to the sugarbeet seed industry.

**Summary of Literature:** *Cercospora* leaf spot has been an intermittent problem in sugarbeet growing areas of the United States where the summers can be hot and humid (Red River Valley, Michigan, Ohio, and, less often, Great Plains growing areas and California). It has been estimated that a severe epidemic can cause up to a 42% loss of gross sugar (Smith and Martin, 1978; Smith and Ruppel, 1973), or up to a 43% relative dollar loss (Shane and Teng, 1992).

Resistance to *Cercospora* leaf spot has long been a goal of the USDA-ARS sugarbeet research

program at Fort Collins and researchers there developed the techniques necessary to manage the screening nurseries in such a way as to promote the development of the disease (Ruppel and Gaskill, 1971). A careful crop rotation (sugarbeet-barley-barley-barley-sugarbeet) and the arid climate and low relative humidity have allowed this to be done in such a manner that there are rarely high enough levels of any other disease present in the leaf spot nursery to confound the results.

There are an estimated 4 or 5 genes responsible for *Cercospora* resistance (Smith and Gaskill, 1970) and broad-sense heritability estimates ranged from 12 to 71% (Bilgen et al., 1969). Narrow-sense heritability estimates of about 24% compared well with realized heritability values, and 44 to 62% of the variation was due environment in this test (Smith and Ruppel, 1974). The large environmental variation has made it difficult to make progress in developing *Cercospora* resistance through mass selection. Incorporation of high levels of leaf spot resistance into varieties with superior agronomic performance also is difficult (Smith and Campbell, 1996) and, therefore, commercial resistant varieties require some fungicide application to provide adequate levels of protection against *Cercospora* (Miller et al., 1994).

A major problem in the development of *Cercospora*-resistant sugarbeet is the loss of vigor due to the continual inbreeding. Coons (1955) noted this and it has been a concern ever since (McFarlane, 1971). The use of hybrid varieties has ameliorated this problem to some extent, but seed production on the highly inbred O-type males and CMS females still is a problem. This is seen in germplasm from both the FC 500 and FC 600 series developed at Fort Collins.

The USDA-ARS National Plant Germplasm System *Beta* collection has over 2,000 Plant Introduction (PI) accessions. The germplasm used most often in sugarbeet breeding is from *Beta vulgaris* spp. *vulgaris*, which includes all of the biennial sugarbeet types, or from *Beta vulgaris* spp. *maritima*, which contains the closely related wild sea beet and has both annual and biennial types. Germplasm with a biennial flowering habit is easier both to introgress and screen. *Beta vulgaris* spp. *maritima* has, nonetheless, been used as a source of resistant germplasm. Much of the *Cercospora*-resistant germplasm in use today came out of Munerati's program in Italy, in which *B. vulgaris* spp. *maritima* was the source of resistance genes (Lewellen, 1992). There have been very few new efforts to locate and incorporate other sources of resistance to *Cercospora* into this narrow germplasm base.

There is an urgent need to continue to create in our *Cercospora*-resistant germplasm a broader genetic base than we have today. As commercial hybrid parents become more inbred, the germplasm base from which these inbred parents are developed must have the diversity necessary to provide for maximum gain through heterosis. Munerati's success, and the research of others, has shown that it can be done if we have the persistence to do it (Bilgen et al., 1969; Doney, 1993; Lewellen, 1995).

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# EVALUATION OF CONTRIBUTED LINES FOR RESISTANCE TO *RHIZOCTONIA SOLANI*, A CAUSAL FUNGUS OF SUGARBEET ROOT ROT. (BSDF Project 903)

E. G. Ruppel (retired) & L. Panella

The breeding program in Fort Collins has created an artificial epiphytotic through inoculation with *Rhizoctonia solani* annually for over thirty years to evaluate and select for resistance to root rot caused by this pathogen. We have been pleased to participate and lead this cooperative research project between the ARS, Colorado State University, and the BSDF. The project primarily involved field studies conducted on 35 acres of leased land near Windsor, CO. Randomized, complete-block designs with five replicates were used to evaluate contributed germplasm. *Rhizoctonia*-resistant line FC703 and highly susceptible FC901/C817//413 were included as internal controls, along with highly resistant FC705-1. One-row plots, planted in mid-May, were 4.3 m (14 feet) long with 56 cm (22 inches) between rows and 20- to 25-cm (8-10 inches) within-row spacing. Fertilization was based on soil test recommendation. The field was sprayed 12 days after planting (dap) with Betamix Progress (1.25 pint/acre) and Upbeet (0.75 oz./acre) and again 22 dap with Betamix Progress (1.25 pint/acre), Upbeet (0.75 oz./acre), and Stinger (0.25 pint/acre). Additional weed control was by hand hoeing and the plots were thinned to 8 in spacing between beets starting about 6 wk after planting.

Stand counts were made on all plots the week before inoculation and inoculation with dry, ground, barley-grain inoculum ( $3.0 \text{ g m}^{-1}$ ) of *Rhizoctonia solani* isolate R-9 was performed on July 10<sup>th</sup>. Immediately after inoculation, a cultivation was performed to throw soil into the beet crowns. Beets were harvested on August 20<sup>th</sup> and 21<sup>st</sup>. Each root was rated for rot on a scale of 0 to 7 (no rot to dead), and plot means for disease index were calculated. Analyses of variance (PROC ANOVA - SAS) were performed on disease indices (DIs), percent healthy roots (classes 0 and 1 combined), and percentage of roots in classes 0 thru 3 (those most likely to be harvested and taken to the factory). Percentages were transformed to arcsin-square roots to normalize the data for analyses. The experimental design, methods, results, and statistical analyses were provided to the appropriate contributors or representatives.

Ample rainfall early in the season, followed by protracted high temperatures and more heavy rain in July and August (Figure 1), led to an extremely severe root rot epidemic in our 1997 nursery. Differences in DIs among entries in all tests were highly significant ( $P < 0.0001$ ). Mean DIs across all tests this year for the highly resistant, resistant, and highly susceptible controls were 3.8, 4.2, and 6.5, respectively (Table 6). Mean percentages of healthy roots were 29.4, 12.5, and 4.2 for these controls. In a normal year, the resistant controls have a DI between 1 and 2, and the susceptible check has a DI between 5 and 6.

**Table 6.** Table below lists the Disease Index in the Experiments in the 1997 *Rhizoctonia* Nursery (4R is in Table 1). It was the most severe epiphytotic in the last 20 years.

Experiment	1R	2R	3R	4R	5R	7R	8R
Susceptible	6.2	6.5	6.9	6.6	6.2	6.8	6.4
Resistant	3.1	3.4	4.6	3.5	4.6	5.3	4.2
Highly Res.	2.7	3.6	3.9	3.2	4.0	4.5	4.9
Test Mean	5.6	6.0	5.9	4.6	5.4	6.0	6.1
LSD	0.8	1.0	1.0	1.2	1.1	1.2	0.8



# **EVALUATION OF CONTRIBUTED LINES FOR RESISTANCE TO *CERCOSPORA BETICOLA*, CAUSAL FUNGUS OF CERCOSPORA LEAF SPOT (BSDF Project 904)**

E. G. Ruppel (retired) & L. Panella

The breeding program in Fort Collins has created an artificial epiphytotic through inoculation with *Cercospora beticola* annually for over forty years to evaluate and select for resistance to leaf spot caused by this pathogen. We have been pleased to participate and lead this cooperative research project between the ARS, Colorado State University, and the BSDF. The project primarily involved field studies conducted on 35 acres of leased land near Windsor, CO.

Randomized complete-block designs, with three replications were used to evaluate breeding germplasm. Internal controls included a highly susceptible synthetic and a resistant check, FC(504 X 502/2) X SP6322-0. Two-row plots were 4 m (12 feet) long, with long with 56 cm (22 inches) between rows and 20- to 25-cm (8-10 inches) within-row spacing. The nursery was planted on May 1<sup>st</sup>. Fertilization was 75% of the soil test recommendation to minimize leaf growth, which can interfere with visual evaluations. The field was sprayed 14 days after planting (dap) with Betamix Progress (1.25 pint/acre) and Upbeet (0.75 oz./acre) and again 26 dap with Betamix Progress (1.25 pint/acre), Upbeet (0.75 oz./acre), and Stinger (0.25 pint/acre). Any additional weed control was by hand hoeing and the plots were thinned to 8 in spacing between beets starting 5 wk after planting.

The *Cercospora* nursery was inoculated twice, on June 27<sup>th</sup> and July 8<sup>th</sup>. Visual evaluations on a scale from 0 (no disease) to 10 (plant dead) were made on September 2<sup>nd</sup>, 9<sup>th</sup>, and 16<sup>th</sup>, with the peak of the epidemic occurring on or about the last date. The 1997 leaf spot epidemic progressed rather slowly at first, but rapidly became quite severe by late August to early September due to high humidity and temperature (Figure 1). At our third evaluation, means of the resistant and susceptible internal controls were 3.7 and 7.3, respectively, across all trials in the nursery (Table 7). An analysis of variance (PROC ANOVA - SAS) on the disease indices (visual evaluation scores) determined that there were significant differences among entries ( $P=0.05$ ) on all three dates (Table 7).

**Table 7.** Disease index ratings of the experiments in the Fort Collins Cercospora nursery in 1997.

		Date of Rating		
		Sept. 2 <sup>nd</sup>	Sept. 9 <sup>th</sup>	Sept. 16 <sup>th</sup>
Experiment 1A	Susceptible Check	5.2	6.3	7.3
	Resistant Check	2.7	3.0	4.5
	Test Mean	3.5	4.5	5.8
	LSD	1.0	1.4	1.3
Experiment 2A	Susceptible Check	5.3	6.7	7.3
	Resistant Check	2.7	2.8	3.5
	Test Mean	4.0	5.1	6.3
	LSD	0.8	1.1	0.9
Experiment 3A	Susceptible Check	4.6	5.6	6.5
	Resistant Check	1.9	2.4	2.9
	Test Mean	3.4	4.0	5.3
	LSD	1.0	1.1	1.1
Experiment 4A	Susceptible Check	6.3	7.0	8.0
	Resistant Check	2.5	2.8	4.3
	Test Mean	4.9	6.0	7.1
	LSD	1.0	1.1	1.4
Experiment 5A	Susceptible Check	5.5	6.8	7.7
	Resistant Check	2.0	2.8	3.3
	Test Mean	4.4	5.7	6.7
	LSD	1.0	1.2	0.9
Experiment 6A	Susceptible Check	5.2	7.2	7.2
	Resistant Check	2.2	2.8	3.2
	Test Mean	4.9	6.5	7.1
	LSD	0.9	1.2	1.0
Experiment 7A	Susceptible Check	5.7	6.8	7.0
	Resistant Check	2.8	3.0	4.0
	Test Mean	4.7	6.0	6.9
	LSD	0.9	1.2	1.0
Experiment 8A	Susceptible Check	5.5	7.0	7.0
	Resistant Check	2.7	3.0	3.8
	Test Mean	3.4	4.2	5.3
	LSD	0.7	0.9	1.0

## **WORLD BETA NETWORK (Special Report)**

Lee Panella

Collections of primitive sugarbeet landraces, heritage sugarbeet varieties, other cultivated forms of beet (including chard), wild beets, and wild relatives of beets are important genetic resources for the sugarbeet breeder. Genes for disease resistance, stress resistance, and yield and quality components can be found in these plants and incorporated into commercial varieties. The World *Beta* Network (WBN) was founded by commercial and public researchers concerned about losses of these genetic resources and under-utilization of the collections containing these resources. It was organized in 1989 by the International Plant Genetic Resources Institute (IPGRI - formerly IBPGR) as an attempt to bring researchers, curators, and germplasm users from both developed and developing nations together to help manage and plan research to solve problems involving *Beta* genetic resources. The next meeting of the WBN will be held in Broom's Barn, UK. The following are minutes of the Beta Co-ordinating Committee (BCC) of the World Beta Network (WBN) from a meeting held at Frauenfeld (Switzerland) on September 19<sup>th</sup>, 1997. The BSDF has been very supportive of the efforts of the WBN, especially in conjunction with the 3<sup>rd</sup> International WBN Conference held in Fargo, ND, and we would like to take this opportunity to thank the BSDF and U.S. Sugarbeet community for their continued support of this important international effort in *Beta* germplasm research.

### **Beta Co-ordinating Committee (BCC) of the World Beta Network (WBN)** Minutes of a meeting held at Frauenfeld (Switzerland) on 19 September, 1997

#### Attending members of the BCC

Dr.M.Asher

Dr.L.Frese (WBN secretary)

Dr.L.Panella

#### Excused

Prof.Sun Yi-Chu

#### Guests

Dr.B.Ford-Lloyd

On the occasion of the 2nd co-ordination meeting of the EU project GENRES CT95 42 and the IIRB study group 'Genetics and Breeding' meeting, the BCC was convened on 19 September, 1997.

The following topics were discussed.

- A follow-up meeting of the Technical Consultative Committee (TCC) of the ECP/GR will be convened at Braunschweig (Germany) probably in June/July 1998. The last meeting of the TCC was held in Slovakia (1995) and is widely known as the 'Nitra meeting'.
- While there is progress with respect to utilization of germplasm, activities in the field of germplasm conservation more and more tend to lag behind. The last two WBN meetings had shown that due to lack of funds many curators of European Beta collections are unable to attend. Clearly, IPGRI's concept of self-sustaining network does not fully function even in the case of a highly industrialized crop. Without the active involvement of all European Beta holdings,

important objectives of the WBN, i.e. task-sharing in the field of maintenance, security duplication etc., and rationalization of collections cannot be fulfilled. In addition, the development of a synthetic Beta core collection (SBCC) requires discussion with all partners at the international level. Furthermore, scientists and genebanks interested in the cultivar groups Leaf Beet and Garden Beet, that are of regional and economically lesser importance, are excluded from meetings. Since most of the collections are located in Europe, there is a particular need for involvement of European genebanks.

- **Recommendations**
  - ⇒ The genus Beta is native to Europe. Hence, there are good arguments for a stronger commitment of the ECP/GR with respect to this genus. As a formalized ECP/GR group within the 'Industrial crops and potato Network' (see Nitra report), it will be possible to receive funds and organizational support from ECP/GR headquarters at Rome, that is needed to resume conservation activities. The TCC meeting at Braunschweig should be used to apply for the establishment of a ECP/GR Beta group.
- It was noted that the publication of the WBN 1996 meeting report is very delayed. One reason is the joint publication of the technical report and scientific papers. The secretary suggested to split the following report in two parts as was done in 1993.
  - **Recommendations**
    - ⇒ IPGRI should be asked to publish the technical report separately as any other technical report. The scientific papers can, for example, be published in the Journal of the ASSBT as in 1993 or any other scientific journal interested in issuing a special edition.
    - ⇒ It was noted that the scientific quality of the papers that are being published in the 1996 report, cannot be within the responsibility of the editors (L.Frese, L.Panella, W.Lange, H.M.Srivastava and S.Padulosi).
- The next WBN meeting will be held at Broom's Barn (England) in 1999.
  - **Recommendations**
    - ⇒ The meeting will consist of a scientific meeting for one day, a technical meeting for another day and half-a-day visits during the third day. A weekend should be included to allow purchase of cheaper flight tickets.
    - ⇒ The secretary will seek funding from IPGRI and other sources.
    - ⇒ The scientific meeting will focus on aspects of germplasm evaluation while the technical meeting should deal with the rationalization of collections, establishment of the core collection etc.. It was noted that the technical meeting could be subdivided into the working groups 1. conservation methods and 2. evaluation methods.
    - ⇒ The BCC will try to identify key speakers for the scientific and technical session. S.Barns from SES ZENECA and A.Raybould (Institute of Terrestrial Ecology, Dorset) were mentioned as potential speakers on diversity research.
    - ⇒ Seed dormancy and hard-seededness is still a problem with respect to handling germplasm collections in genebanks and evaluation programmes. L.Frese agreed to contact the seed physiology experts of Kew Gardens.
    - ⇒ Since the WBN meeting will take place at Broom's Barn where currently research into the utilization of Beta germplasm is intensified, more scientists may want to attend. 50 participants was deemed to be a realistic number.
    - ⇒ The meeting fee will again be \$100.00 US.

- L.Frese raised the question of improved task-sharing within the BCC.
- **Recommendations**
  - ⇒ The secretary is responsible for running of the International Data Base for Beta (IDBB) as well as for the promotion of the WBN work plan implementation.
  - ⇒ M.Asher is responsible for the local organization of the next WBN meeting.
  - ⇒ BCC members can only be elected twice. Since L.Panella will have to withdraw from the BCC in 1999, he volunteered to act as the general chairman of the WBN 1999 meeting. The secretary suggested contacting Prof.Sun Yi-Chu and asking for his opinion. (Prof.Sun Yi Chu was asked in mid November and agreed to the suggested task-sharing and the election of L.Panella as general chairman).

# EVALUATION OF USDA-ARS GERMPLASM AND CROATIAN BREEDING LINES FOR RESISTANCE TO CERCOSPORA LEAF SPOT AT MULTIPLE LOCATIONS IN 1997. (Special Report)

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Thirty-five Fort Collins germplasm and 35 breeding lines from the Institute for Sugarbeet Breeding in Osijek, Croatia were screened at three locations: 1) an artificially produced epiphytotic (Ruppel, E.G., and J.O. Gaskill. 1971. Techniques for evaluating sugarbeet for resistance to *Cercospora beticola* in the field. J. Am. Soc. Sugar Beet Technol. 16:384-389) in Fort Collins, CO; 2) an artificially produced epiphytotic in Osijek, Croatia; and 3) a naturally occurring epiphytotic in Osijek, Croatia. Randomized complete-block designs, with two replications were used to evaluate germplasm. Internal controls included a highly susceptible synthetic check and a resistant hybrid check, FC(504 X 502/2) X SP6322-0. Two-row plots were 4 m long, with 56 cm between rows and 20- to 25-cm within-row spacing. The artificially inoculated nurseries were inoculated twice, on June 13<sup>th</sup> and 23<sup>rd</sup> in Osijek, and on June 27<sup>th</sup> and July 8<sup>th</sup> in Fort Collins. Visual evaluations on a scale from 0 (no disease) to 10 (plant dead) of PIs in the natural and artificial *Cercospora* epiphytotics were made in Croatia on August 8<sup>th</sup>, 18<sup>th</sup>, and 28<sup>th</sup>. Evaluations in Fort Collins were made on September 2<sup>nd</sup>, 9<sup>th</sup>, and 16<sup>th</sup>, with the peak of the epidemic occurring on or about the last date. This project was supported by the USDA-ARS NPGS and USDA/FAS/RSED grant HR02.

In Fort Collins, the 1997 leaf spot epidemic progressed rather slowly at first, but rapidly became quite severe by late August to early September. At our third evaluation, means of the resistant and susceptible internal controls were 3.7 and 7.3, respectively, across all trials in the nursery. An analysis of variance (PROC ANOVA - SAS) on the disease indices (visual evaluation scores) determined that there were significant differences among entries ( $P=0.05$ ) on all three dates at all three locations. An LSD was generated for mean separations. Although the variation was higher in Osijek, some entries performed very differently at the different locations.

**Table 8.** Disease index rating of the 70 lines at the peak of the *Cercospora* epiphytotic in three locations. Tukey's procedure was used to separate means in order to maintain a 5% measure of significance across the entire test.

Source	Designation	Fort Collins Sept. 16 <sup>th</sup>	Osijek artificial August 28 <sup>th</sup>	Osijek Natural August 28 <sup>th</sup>
Tukey's Minimum Significant Difference <sub>(0.05)</sub>		2.4	3.4	2.8
931002	LSS	6.5	8.0	4.7
821051H2	LSR	2.9	2.0	2.0
86A047	FC607CMS (4x )	2.9	2.0	1.0
911026HO	FC715	3.3	3.0	2.3
921024	FC709-2	3.5	3.7	2.3
831085HO	FC708	3.8	2.7	2.0
921022	FC702-7	3.9	4.7	4.0
79A067	FC607	3.9	2.0	2.0

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Tukey's Minimum Significant Difference <sub>(0.05)</sub>		2.4	3.4	2.8
931002	LSS	6.5	8.0	4.7
821051H2	LSR	2.9	2.0	2.0
781035HO	FC606	3.9	3.3	2.7
961014	FC724	4.0	4.0	2.7
771067HO	FC504	4.0	2.3	2.0
pollinator (2n=4X=36)		4.1	3.7	3.3
781035HO1	FC606CMS	4.1	3.0	2.3
961015	FC720	4.1	2.7	2.0
86A048	FC607 (4x)	4.3	2.3	2.3
931005HO1	FC721CMS	4.4	3.7	2.3
pollinator (2n=4X=36)		4.4	3.3	3.3
921021	FC703-5	4.4	4.0	2.0
961010HO	FC722	4.6	5.0	3.7
CMS line (2n=4X=36)		4.6	3.3	2.0
891037	AD2 (4x)	4.6	4.3	2.7
pollinator (2n=4X=36)		4.6	4.3	3.3
951017	FC727	4.8	5.0	3.0
961011HO	961011HO	4.8	2.7	2.3
pollinator (2n=4X=36)		4.8	3.7	2.3
831028HO	FC506	4.9	2.7	2.0
86A046	FC606 (4x)	4.9	3.7	4.0
911031	FC717	4.9	5.0	3.0
CMS line (2n=4X=36)		5.0	2.3	1.7
CMS line (2n=4X=36)		5.0	3.7	2.3
961010HO1	FC722CMS	5.0	4.3	3.0
CMS line (2n=4X=36)		5.1	2.3	1.7
CMS line (2n=4X=36)		5.1	3.7	1.7
961011HO1	961011HO1	5.1	2.0	2.0
731028HO	FC902	5.1	2.7	2.7
931005HO	FC721	5.3	3.3	2.7
pollinator (2n=4X=36)		5.3	3.3	2.7
pollinator (2n=4X=36)		5.3	4.7	2.3
pollinator (2n=2X=18)		5.3	6.0	4.0
CMS line (2n=2X=18)		5.4	5.0	2.3
pollinator (2n=2X=18)		5.4	3.7	2.3
951016HO1	FC723CMS	5.4	4.7	3.3
921025	FC728	5.5	4.3	3.0
911042HO	FC402	5.5	5.3	3.0
911042HO1	FC402CMS	5.5	6.0	3.7
86A045	FC606CMS (4x )	5.6	3.0	2.7
951016HO	FC723	5.8	5.0	3.7
pollinator (2n=4X=36)		5.8	5.3	3.0

**Table 8.** Disease index rating of the 70 lines at the peak of the *Cercospora* epiphytotic in three locations. Tukey's procedure was used to separate means in order to maintain a 5% measure of significance across the entire test.

Source	Designation	Fort Collins Sept. 16 <sup>th</sup>	Osijek artificial August 28 <sup>th</sup>	Osijek Natural August 28 <sup>th</sup>
Tukey's Minimum Significant Difference <sub>(0.05)</sub>		2.4	3.4	2.8
931002	LSS	6.5	8.0	4.7
821051H2	LSR	2.9	2.0	2.0
pollinator (2n=4X=36)		5.9	5.0	2.7
pollinator (2n=4X=36)		5.9	4.3	2.7
pollinator (2n=2X=18)		6.0	6.3	3.7
pollinator (2n=2X=18)		6.1	5.0	4.0
pollinator (2n=2X=18)		6.1	4.3	3.0
pollinator (2n=2X=18)		6.1	4.0	3.0
pollinator (2n=2X=18)		6.1	6.3	4.0
CMS line (2n=2X=18)		6.1	4.7	3.3
pollinator (2n=2X=18)		6.3	5.0	4.0
pollinator (2n=2X=18)		6.3	6.7	4.3
CMS line (2n=2X=18)		6.4	5.7	4.0
CMS line (2n=2X=18)		6.5	4.3	2.7
CMS line (2n=2X=18)		6.6	3.3	3.3
CMS line (2n=2X=18)		6.6	7.0	4.3
pollinator (2n=4X=36)		6.6	6.7	4.7
CMS line (2n=2X=18)		6.8	6.0	4.3
pollinator (2n=2X=18)		7.0	6.0	4.0
CMS line (2n=2X=18)		7.0	4.3	3.3
CMS line (2n=2X=18)		7.1	4.7	4.0
911043HO1	FC403CMS	7.3	8.3	5.0
CMS line (2n=2X=18)		7.4	5.0	3.3
911043HO	FC403	7.8	8.7	5.3



**SUGARBEET RESEARCH**

**1997 REPORT**

**Section C**

**U.S.DA, A.R.S, Western Regional Plant Introduction Station  
Pullman, Washington**

**Dr. Alan Hodgdon, *Beta* Curator**

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**This research was supported in part by funds provided through the  
Beet Sugar Development Foundation (Project 290)**



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Status Report on the Beta germplasm Collection Activities . . . . . by A. Hodgdon	C 3



**Status report on the *Beta* germplasm collection activities  
at the USDA, ARS, Western Regional Plant Introduction Station  
To the Beet Sugar Development Foundation  
Curator: Dr. Alan Hodgdon, 1998**

Currently there are 91 accessions being increased under either field or greenhouse conditions. There are 537 accessions on the priority list needing increase, down from 685 last year. There are 108 accessions of hard seeded species yet to increase. Ten of these are currently being grown for seed, and six have been finished. The following table shows the increase results since the program at W-6 started.

**Increase Activity**

<i>Year</i>	<i>Started</i>	<i>No Germ</i>	<i>Harvested</i>	<i>Carry over</i>
1995	94	5	79	10
1996	62	6	47	4
1997	92	4	28	60
1998	20 (60 more expected)			Don't know yet
Hillesog	13			13

The attached table lists most of the increases completed in 1997. There were 26 isolated greenhouse increases (GH). Seventeen of these rated good, 8 were fair, and 1 was poor. There were 24 accessions increased with isolation in the field at Central Ferry (CF). Nine rated good, 8 were fair and 7 were poor. Good increases yielded over 10,000 seed and 1 or more gm/ 100 seed. Fair increases had less than 10,000 seed or less than 1 gm/100 seed. Poor increases yielded less than 10,000 seed and less than 1gm/100 seed. Poor results at CF resulted mostly from poor winter survival and some problems with pest control. We are expecting the 13 lines from Hillesog increase this year.

The increase project at W-6 is clearly hampered by a lack of enough greenhouse space and lack of a reliable vernalization facility. During the federal fiscal year '98, we are trying to order a prefabricated, self contained vernalization chamber that will be big enough to satisfy all of our vernalization requirements at the PI Station. This will be a new piece of equipment and hopefully will give us more accurate control of our vernalization light and temperature conditions.

We now have a freezer in operation for -20 C storage of samples of original seed and regeneration samples. These samples have been identified, and most are packaged and are ready for bar coding and freezing. We are also continuing with seed germination tests, and in 1998 we will test the 1996 harvested seed.

Last year we distributed 406 *Beta* accessions. Twenty-six new accessions were added to the collection.

PRE	ACCNO	SUFF	G R O W #	PLANTS	100 WT	Yield g	Yield #	EVAL.
			LOC					
NSL	80223	96i	CF	98	1.2	230	19170	good
NSL	81098	96i	CF	30	1.7	224.6	13210	good
NSL	93284	96i	CF	13	0.8	101.7	12710	good
PI	117115	96i	CF	7	1.4	107.8	7700	fair
PI	142812	96i	CF	5	0.5	4.8	960	poor
PI	169019	95i	CF	12	0.8	52.3	6540	fair
PI	169027	96i	CF	14	0.6	35.8	5970	poor
PI	171507	96i	CF	6	1.2	37	3080	fair
PI	172730	96i	CF	10	1.6	190	11900	good
PI	181717	96i	CF	30	0.8	160	20000	fair
PI	232894	96i	CF	24	1.3	224	17230	good
PI	264350	96i	CF	1	5.2	37.4	720	fair
PI	264351	96i	CF	7	3.5	162.5	4640	good
PI	264352	96i	CF	26	2.4	105.6	4400	good
PI	269308	96i	CF	15	0.6	26.1	4350	poor
PI	271440	97i	CF	96	0.5	31.2	6240	poor
PI	386206	96i	CF	20	1	268.6	26860	good
PI	486356	96i	CF	11	1.8	214	11900	good
PI	486357	96i	CF	23	1.1	87.2	7930	fair
pi	507851	96i	CF	20	0.7	51.5	7360	poor
PI	518303	95i	CF	24	0.7	110	15710	fair
PI	546512	97i	CF	96	1.2	9.8	810	poor
PI	546515	97i	CF	12	1.8	27.6	1290	poor
PI	546521	97i	CF	96	1	64.1	6410	fair
A	4464	96i	GH	15	1	321	32100	good
A	8300	97i	GH	67	2.1	468	22300	good
NSL	93277	96i	GH	89	2	820	41000	good
NSL	93279	96i	GH	43	1	307.1	30710	good
NSL	95217	97i	GH	39	1.3	415.6	31970	good
NSL	95218	97i	GH	9	0.9	108	12000	fair
PI	140360	97i	GH	11	1.4	190	13570	good
PI	142809	96i	GH	20	1.2	693	57750	good
PI	164172	97i	GH	71	0.9	146	16200	fair
PI	174060	97i	GH	47	1	904	90400	good
PI	179178	97i	GH	7	1.3	29	2230	fair
PI	271270	97i	GH	57	0.6	160	26700	fair

PI	277270 97i	GH	84	1.2	332.1	27670	good
PI	296538 96I	GH	8	0.5	2.9	580	poor
PI	368376 96i	GH	16	1	87	8700	fair
PI	379097 96i	GH	5	1.4	84.4	6030	fair
PI	386206 96i	GH	40	1.2	211.4	17620	good
PI	490993 96i	GH	83	1.4	728	52000	good
pi	491195 96i	GH	55	1	257	25700	good
PI	504180 96i	GH	2	1.4	122.4	8740	fair
PI	546455 97i	GH	94	2	212.3	10615	good
PI	546508 97I	GH	56	1.6	214.1	13380	good
PI	546518 97i	GH	94	1	525	52500	good
PI	546520 97i	GH	13	1.4	117.9	8420	fair
PI	546534 97i	GH	74	1.3	825	63460	good
PI	596528 96i	GH	58	1.5	299.2	19946	good





# **SUGARBEET RESEARCH**

## **1997 Report**

### **SECTION D**

Northern Crop Science Laboratory, Agricultural Research Service,  
U.S. Department of Agriculture, Fargo, North Dakota

#### **SUGARBEET AND POTATO RESEARCH UNIT**

Dr. G.A. Smith, Research Leader, Geneticist  
Dr. L.G. Campbell, Geneticist  
Mr. J.D. Eide, Plant Physiologist  
Ms. R.L. Stolzenberg, Microbiologist  
Dr. J.J. Weiland, Plant Pathologist  
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#### *Cooperation:*

Sugarbeet Research and Education Board of MN and ND  
University of Minnesota, Crookston  
North Dakota State University

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## PUBLICATIONS

### *Abstract of papers Presented, Published or Approved for Publication*

**Campbell, L.G., G.A. Smith, J.D. Eide, A.W. Anderson, and L.J. Smith. 1997. Alternatives to insecticides for control of the sugarbeet root maggot. Proc. 60th Congress of the International Institute for Beet Research, p 419-421.**

The sugarbeet root maggot is a serious insect pest of sugarbeet in North America. Larvae feed on developing sugarbeet by tunneling along the root surface. Feeding causes yield losses by reducing stands early in the season and/or reducing root yields at harvest. Insecticide applied at planting is the primary control method. One resistant line, F1015, was released to breeders in 1996. Sugarbeet root maggot damage to F1015, as evidenced by number and size of feeding scars, is substantially less than for any commercial hybrid tested. The entomopathogenic fungi *Metarhizium anisopliae* has been the most successful root maggot biocontrol agent we have identified, to date. Damage ratings and yield data from two environments indicate that a fall (preceding planting) plus spring (planting time) application of fungi provides better control than a single application either spring or fall.

**Campbell, L.G., K.B. Thorsness, and P. Mayland. 1998. Storage respiration of Liberty-Link sugarbeet hybrids. 1997 Sugarbeet Research and Education Reports (North Dakota State Univ.) 28: 359-360.**

The commercialization of transgenic varieties of crop plants has made this new technology the subject of much discussion. Herbicide resistant transgenic sugarbeet hybrids are currently being examined on an experimental basis and likely will be the first transgenic sugarbeet grown commercially in the region. Producer interest in these hybrids is high, because of the additional weed control options they provide. Sugarbeets are unique in that they are stored in large exposed piles between harvesting and processing. During this storage period the roots continue to respire; consuming sugar in the process. Therefore; any change in production practice or genetic makeup of the hybrids that affects storage respiration rate is of economic importance. The objective of this study was to determine if the alien gene that provides resistance to Glufoniate-ammonium (a broad spectrum herbicide sold under the trade name Liberty) affected respiration rate during storage. The results suggested that neither this particular introduction of a herbicide-resistance gene nor the application of the corresponding herbicide affected storage respiration of sugarbeet.

**Campbell, L.G., G.A. Smith, H.A. Lamey, and A.W. Cattanach. *Cercospora beticola* Tolerant to Triphenyltin Hydroxide and Resistant to Thiophanate Methyl in North Dakota and Minnesota. Journal of Sugarbeet Research (submitted for publication).**

Triphenyltin hydroxide (TPTH) has been used extensively for control of *Cercospora* (*Cercospora beticola*) leaf spot of sugarbeet (*Beta vulgaris*) in Minnesota and North Dakota following the development of benzimidazole resistant strains in the early 1980s. The discovery of tolerance to TPTH in 1994 prompted extensive sampling throughout the region in 1995 and 1996. In 1995, 60% of the leaf spots in the southern most district were tolerant to 0.2ppm TPTH and 42% tolerant to 1ppm. By 1996 these frequencies had increased to 83 and 60%, respectively. More alarming than this increase in the southern district was the rapid increase in the occurrence of tolerance further north where the disease is generally less severe and fungicide use is less. In four of the seven factory districts the frequency of leaf spots tolerant to 0.2ppm exceeded 35% and the frequency tolerant to 1ppm was greater than 15%, in 1996. Resistance to thiophanate-methyl, a benzimidazole-type fungicide, persisted in local populations even though TPTH has been the predominant fungicide for control of *Cercospora* leaf spot for about 15 years.

**Smith, G.A., L.G. Campbell, and J.D. Eide. Progress in control of sugarbeet root maggot via Pathogenic Fungi. 1997 Sugarbeet Research and Extension Reports, p. 258-260.**

Our extensive laboratory research and our limited field tests suggest that *Metarhizium anisopliae* may be effective in controlling the sugarbeet root maggot. A three-year field study was initiated with *M. Anisopliae* to determine persistence of the fungi over seasons and rotations. Spring and fall 1996 treatments combined with a spring 1997 treatment resulted in significantly more sugar than all other treatments. This treatment produced 400 pounds more sugar than the Lorsban treated plots and 1400 pounds more than the untreated control plots. Questions needing further research include application rates, timing of treatments, location effects, and application methods. We are continuing our field test in a sugarbeet/cereal rotation and have added another location for our 1998 field evaluations.

**Weiland, J.J., and G.A. Smith. A Survey for the Prevalence and Distribution of *Cercospora beticola* Tolerant to Triphenyltin Hydroxide and Mancozeb and Resistant to Thiophanate Methyl in 1997. 1997 Sugarbeet Research and Extension Reports, p. 315-318.**

Triphenyltin hydroxide (TPTH) has been used extensively in the Northern Great Plains in recent years for the control of *Cercospora* leaf spot on sugarbeet. Although mancozeb and, to a lesser extent, the benzimidazole fungicides often are implemented in conjunction with TPTH for optimum leaf spot control, TPTH continues to be the most widely used compound for control of the disease.

Testing in our USDA-ARS Fargo laboratory of *Cercospora* that was isolated from leaf spot in the sugarbeet fields in North Dakota and Minnesota for the tolerance or resistance to fungicides first revealed tolerance to TPTH in 1994. The testing program has continued to the present and includes, for the first time, extensive surveying for tolerance to mancozeb. As in previous years, fields in the southern Minnesota growing region and in all factory districts from Wahpeton to Drayton in the Red River Valley were surveyed. Samples were tested for resistance to thiophanate methyl (TM; a benzimidazole fungicide) and for tolerance to TPTH and mancozeb at two different exposure levels.

## **CERCOSPORA LEAF SPOT AND BIOPESTICIDE RESEARCH**

### ***Project 601***

**G.A Smith and J. D. Eide**

The gene and gene products involved in *Cercospora* resistance are being examined. A 26 kD glucanase was purified by chromatography and electrophoresis. The glucanase protein was transblotted to PVDF membrane for amino acid sequencing. The N-terminal amino acid sequence is as follows: H<sub>2</sub>N- Thr Thr Phe Thr Val Val Asn Asn Cys Gln. A search of 'Genbank' confirmed that this is a new antifungal protein. The closest homology was to the antifungal peptides avematin and osmotin-like protein. We have used this sequence to construct two PCR primers for the detection of antifungal genes in sugarbeet. The primer sequence is as follows: 5'TCTAGAATTTCACIGTIGTIAACAACACTGCCA3' and 5' CCTAGGATCCTTTTTTTTTTTT 3'. These primers will be used to isolate the above gene from a cDNA library.

RNA has been isolated from *Cercospora* infected leaf spot resistant material for use in construction of a cDNA library. This library will be used for detection and cloning of the 26 kD antifungal protein. RNA has been extracted from leaf spot susceptible material for construction of a library to be used in differential display. Any new pathogenesis related proteins detected will be cloned from this differential display library.

We are continuing to examine the presence of chitinase genes in leaf spot resistant, leaf spot susceptible and wild Beta germplasm. The PCR (polymerase chain reaction) was used to amplify the DNA sequence complementary to the SE2 chitinase gene. The primers detected the SE2 chitinase gene in all beets grouped into the Beta and Corollinae section including *Cercospora* leaf spot resistant check, leaf spot susceptible check (*Beta vulgaris*, *B. maritima*, *B. atriplicifolia*, *B. corolliflora*, *B. trigyna*, *B. lomatazona* and *B. macrorrhiza*. PCR detected no 476 bp fragment in the Procumbens section of beets containing *B. patellaris*, *B. procumbens* and *B. webbiana*.

## **SUGARBEET ROOT MAGGOT BIOPESTICIDE RESEARCH**

### ***Biopesticide Laboratory Research***

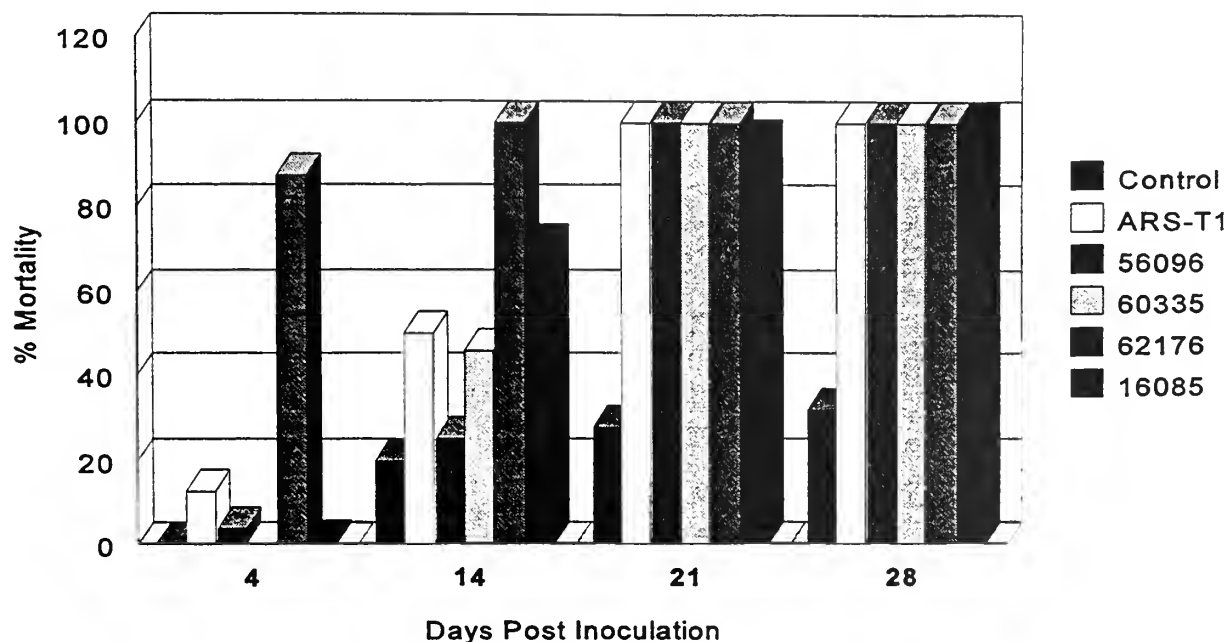
Our previous studies have shown the efficacy of the entomopathogenic fungi ARS-T1 (*M. anisopliae*) on first instar SBRM (Sugarbeet root maggot), third instar SBRM and adult flies. New strains of *Metarhizium anisopliae* are being tested as a biocontrol agent for control of *Tetanops myopaeformis* (Sugarbeet Root Maggot).

The new strains of *M. anisopliae* being tested against SBRM are principally from Brazil and Canada. Third instar SBRM were inoculated with  $2.3 \times 10^7$  conidia/ml of *M. anisopliae* ATCC#56096, 60335, 62176, or 16085. The mortality was 100% for all strains twentyone to twentyeight days post inoculation (Fig. 1). These strains have a similar efficacy to our ARS-T1. ARS-T1 will be tested against other orders of insects to determine its potential use on other

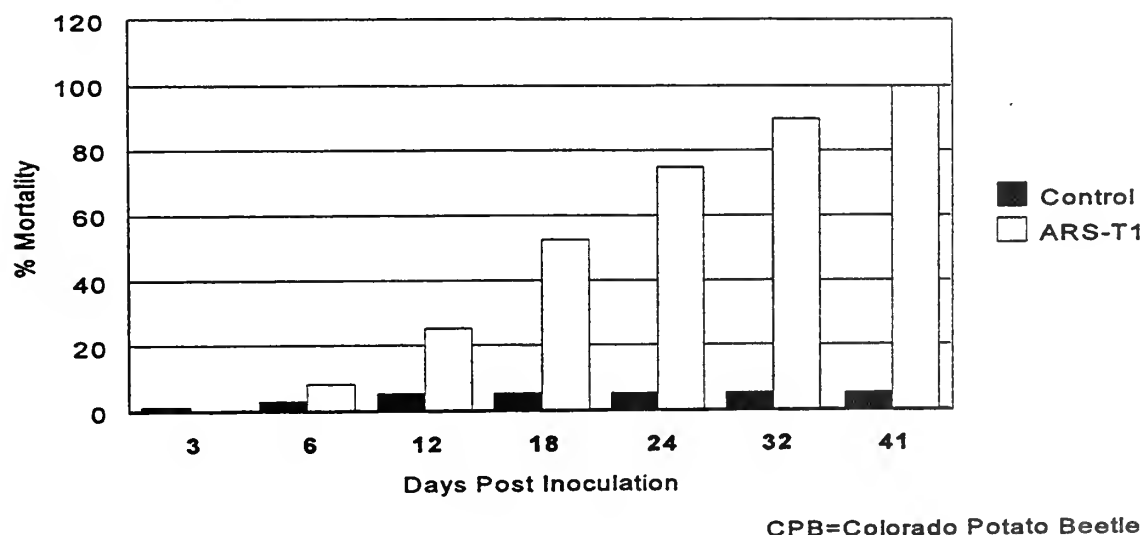


sugarbeet pests (i.e. wireworms, cutworms nematodes). ARS-T1 was effective against the Coleopteran, Colorado potato beetle (Fig.2). Twenty four days after exposure to ARS-T1, mortality was 90%. Another *M. anisopliae* (ATCC#62176 isolated from *Heterodera glycines*) may have potential to control sugarbeet root knot nematodes. We will continue to test biocontrol agents for use in an integrated pest management system for control of SBRM.

**Fig. 1. Mortality of 3<sup>rd</sup> instar sugarbeet root maggots inoculated with 5 different strains of *M. anisopliae*.**



**Fig. 2 Percent mortality of Colorado Potato Beetle inoculated with *M. anisopliae* strain ARS-T-1.**



Molecular techniques are facilitating the development of a fungal biopesticide. We have successfully isolated DNA from new entomopathogenic fungal strains of *Metarhizium anisopliae*. This DNA is being used for the isolation, cloning and sequencing of an actin gene. Current detection techniques for entomopathogenic fungi are laborious and inexact. We have been testing PCR primers specific for actin genes for detection of the entomopathogenic fungus *M. anisopliae* (Primers provided by Dr. John Weiland). We are preparing a rapid detection method using PCR for strains of fungi pathogenic to SBRM. A 1.3 kbp DNA fragment has been synthesized using PCR with primers specific for the 5' end of the actin gene in ARS-T1 (*M. anisopliae*). We have isolated, cloned and sequenced the actin gene in four other strains of *M. anisopliae* and one of *M. flavoviride*. These sequences are being compared to ARS-T1.

The middle section of the actin gene has been cloned and sequenced to provide internal sequence information for primer synthesis. Primers from this sequence information have been synthesized and specificity for ARS-T1 is being examined. These primers will be used for a rapid detection test of *M. anisopliae* in soil, rhizosphere or diseased insects.

Production of *M. anisopliae* conidia on heat killed barley is being fine tuned. We have been able to produce over 2500 pounds of inoculum this past year. We are continuing to examine long-term viability of *B. bassiana* and *M. anisopliae*. The fungi are stable under varying temperatures and time in storage. (Table 1) Production of spores using air batch cultures and fermentation is being examined to facilitate application technologies for delivery of ARS-T1 in a practical and economically feasible method.

**Table 1. Viability of *B. bassiana* and *M. anisopliae* under different temperature regimes (+ = still viable, Nd = not determined)**

Temperatures		Months in Storage				
		5	21	34	45	47
<i>M. anisopliae</i>	20°C	+	+	+	+	+
"	-20°C	+	+	+	+	Nd
"	-80°C	+	+	+	+	Nd
<i>B. bassiana</i>	20°C	+	+	+	+	+
"	-20°C	+	+	+	+	Nd
"	-80°C	+	+	+	+	Nd

### ***Biopesticide Field Studies***

**G. A. Smith, L.G. Campbell, and J. D. Eide.**

Our previous laboratory studies have shown the efficacy of the entomopathogenic fungi *Metarhizium anisopliae* on first and third instar sugarbeet root maggots (SBRM). Mortality at the most damaging 3rd instar stage was over 90% fourteen days after exposure. The fungi are also effective against adult flies. Six days after inoculation, mortality rates were 100% for *M. anisopliae* treated adult flies.

A key to the success of pathogenic fungi may be the establishment and/or buildup in the soil and the maggot populations preceding a natural epizootic. By comparing their maintenance with time through a typical crop rotation scheme, we will determine their efficacy as a management strategy for the root maggot.

We are in the second year of a three-year field study which was initiated to determine the persistence of *M. anisopliae* over seasons and rotations. Autoclaved barley (as a carbon source) inoculated with *M. anisopliae* was dried and applied; in the spring immediately prior to planting, in the fall preceding planting, or fall plus spring and tested in replicated field plots at Crookston, MN, in 1996, 1997 and 1998.

## Results and Discussion

Table 2 summarizes the effects of *M. anisopliae*, Lorsban and no treatment on root yield and sugar percentage in 1997. For purposes of this discussion *M. anisopliae* is referred to as ARS T-1. All treatments exceeded the control for root yield with the ARS T-1 spring 96 plus fall 96 plus spring 97 treatment being equal to the Lorsban treatment. Plots which were treated with ARS T-1 in the spring of 96 and double treated in the spring of 97 also equaled the Lorsban treatment. Sugar percentage was significantly greater with the spring 96 plus fall 96 plus spring 97 ARS T-1 treatment than the check or Lorsban treatment. A trend toward this result was seen in 1996, however, this is the first year that a statistically significant difference was seen.

**Table 2. Root Yield and Sugar Percentage of *Metarhizium anisopliae* (ARS T-1) and Lorsban Untreated Sugarbeets, 1997 Field Tests**

Root Yield, Sugar %		
Treatment	Root Yield	% Sugar
Lorsban	25.70 a	15.1 b
ARS T-1		
Spr + Fall 96 + Spring 97	25.69 a	15.8 a
Spr 96 + Spr 97	22.97 b	15.0 bc
Spr 96 + Spr 97 (Dbl)	25.24 a	14.6 c
Spr 96 + Fall 97	23.48 b	14.8 bc
Control	21.74 c	15.1 c

\*Means within columns followed by the same letter are not significantly different.

Table 3. summarizes the effects of *M. anisopliae* on recoverable sugar per acre as compared to Lorsban and the untreated control. The ARS T-1 spring 96 plus fall 96 plus spring 97 treatment resulted in significantly more sugar than all other treatments. This treatment produced 400 pounds more sugar than the Lorsban treated plots and 1400 pounds more than the untreated control plots.

**Table 3. Recoverable Sugar Per Acre of *Metarhizium Anisopliae* (ARS T-1), Lorsban, and Untreated Sugarbeets, 1997 Field Tests**

Recoverable Sugar Per Acre	
Treatment	Sugar Lbs.
Lorsban	6766 b
ARS T-1	
Spr + Fall 96 + Spr 97	7167 a
Spr 96 + Spr 97	6035 cd
Spr 96 + Spr 97 (Dbl)	6312 c
Spr 96 + Fall 97	6043 cd
Control	5725 d

*\*Means followed by the same letter are not significantly different.*

For both 1996 and 1997, Table 4 presents the results of the best biocontrol using *M. anisopliae* (ARS T-1 strain) compared to Lorsban and untreated controls for recoverable sugar. The best biocontrol treatments always involved spring and fall application of ARS T-1. As can be noted, the ARS T-1 treatment equaled Lorsban in 1996 and significantly exceeded it in 1997.

**Table 4. Lorsban vs Best Biocontrol 1996, 1997  
Recoverable Sugar (Pounds per Acre)**

Treatments	Means	
	1996	1997
Lorsban	7748 a	6766 b
ARS T-1 ( <i>M. anisopliae</i> )	8074 a	7167 a
Control	6388 b	5725 c

*\*Means within the same column followed by the same letter are not significantly different.*

### Conclusions

Our extensive laboratory research and our limited field tests suggest that *M. anisopliae* may be effective in controlling the sugarbeet root maggot. Questions needing further research include application rates, timing of treatments, location effects, and application methods. We are continuing our field test in a sugarbeet/cereal rotation and have added another location for our 1998 field evaluations.

# DEVELOPMENT OF A GREENHOUSE ASSAY FOR RESISTANCE TO RHIZOCTONIA ROOT ROT

*Project 610*

J.J. Weiland and G.A. Smith

Previously we showed that the resistance to *Rhizoctonia* root rot in germplasm derived from mass selection could be detected after plant inoculation in the greenhouse. The results from those experiments suggested that performance of the test in the greenhouse during the winter months might bias the scoring of known resistant accessions towards susceptibility.

The following report summarized a more extensive test of the greenhouse assay for *Rhizoctonia* resistance which examined several germplasm releases inoculated over several dates throughout 1997. The technique briefly summarized is as follows: Plants (one per 6" pot) are grown to the 5 week stage before inoculation. *Rhizoctonia solani* AG2-2 is inoculated to sterile barley grains and is allowed to colonize the grain for 2-3 weeks. The infested grain is used to inoculate the 5 week old plants; two infested grains are placed together approximately 0.5" below the soil surface and touching the root surface. Soil is replaced over the inoculum grain. Plants are rated for root rot disease at 14 days post-inoculation. Healthy (resistant) plants possess small or no lesions. Previous results indicated that 100% of the plants of a susceptible variety (Ultramono) became diseased and/or wilted when subjected to this assay.

Testing was designed to have FC709-2, an accession highly resistant to *Rhizoctonia* root rot over several years of testing in the Fort Collins *Rhizoctonia* root rot nursery, as the resistant check. 'Ultramono' served as a susceptible check, while FC718, FC715, FC717, FC403cms, FC708, FC604 and FC907 possessed intermediate reactions in trials in the Fort Collins nursery. The inoculum used was *Rhizoctonia solani* AG2-2 strain R9, the same strain used for inoculation of the nursery at Fort Collins, CO. Plants were grown and maintained in a greenhouse with a temperature of 22°C and a day length of 16 hr (using supplemental lighting).

Table 1 shows the results of rating of 50 roots of each accession tested. Rating of root rot in the greenhouse assay is done on 7 to 8 week old plants, so caution must be exercised in comparing the disease rating from this assay with the root rot ratings from the Fort Collins nursery. Ranking of the accessions by disease severity induced by *R. solani* R9 in the greenhouse assay clearly shows agreement with the general ranking of these accessions by their performance in the root rot nursery from 1994, 1995, and 1996. The percent of roots that possessed disease reactions in the class of 1-2 (poor lesion formation) is a measure of the relative resistance of that germplasm source to resistance. Accessions FC709-2, FC718, FC708, FC717 and FC715 were characterized by a greater percentage of roots in the 1-2 reaction class than that of the other roots. Accessions FC403cms, FC907, and FC604 have tended towards susceptibility in the root rot nursery, a result that is reflected in the root rot ratings from the greenhouse assay.

The results validate the evaluation of root rot by inoculation in the greenhouse of 5 week old sugarbeet plants. Previously, roots demonstrating resistance using the assay were induced to

flower and were interpollinated. The resistance in the progeny from these crosses will be evaluated in the root rot nursery in Fort Collins, CO in 1998. The assay also will be used in 1998 to evaluate the inheritance of resistance in defined populations segregating for root rot resistance.

**Table 1. Results from the 1997 *Rhizoctonia* greenhouse assay.**

Accession	Assay Date <sup>a</sup>	%HP <sup>b</sup>	FCN-1996 <sup>c</sup>	FCN-1995 <sup>d</sup>	FCN-1994 <sup>e</sup>
FC718	7/16/97	90	80/1.27	53/1.52	75.4/1.38
FC709-2	"	86	100/0.85	55/1.5	86/1.01
FC717	"	66	81.3/1.38	36.5/1.98	43.1/2.14
FC715	"	66	68.6/1.47	37.6/1.72	60.3/1.68
FC708	"	38	90.6/1.09	57.1/1.62	58.9/1.69
FC907	"	28		14.3/3.28	
FC604	"	20		7.1/3.9	12.5/4.46
Ultramono	"	18			
FC403cms	"	12		3.7/4.3	

<sup>a</sup> 5 week-old plants were inoculated with barley grain infested with *R. solani* isolate R9. Two weeks post-inoculation, roots were pulled, cleaned free of soil and evaluated for root rot severity.

<sup>b</sup> The proportion of roots (out of 50 total per accession) exhibiting a reaction of 0 (no symptoms) or 1 (small, surface lesions).

<sup>c,d,e</sup> Data from 1996, 1995, and 1994 Fort Collins *Rhizoctonia* nursery (percent healthy plants/disease index rating; rating of 0=healthy plant to 7=dead).

**BROADENING THE GENETIC BASE OF SUGARBEET**  
*Project 630*

**L. G. Campbell**

The narrow genetic base of most sugarbeet breeding pools has been recognized by breeders as a potential restriction to progress. Continued gains in productivity are contingent upon incorporation of genetic variation into breeding populations. The aim of this project is to incorporate genetic variation from wild *Beta* populations into sugarbeet populations that are readily utilized by applied sugarbeet breeders.

**INDIVIDUAL ROOT SAMPLING (SUGAR) OF CROSSES BETWEEN  
RELEASED FARGO LINES (L53CMS / PI 546420) AND L19**

Y317, y318, y322, and y387 are released germplasms (developed by D. L. Doney) all derived from the cultivated / maritima cross, L53 / PI 546420. PI 546420 was collected near Thessaloniki, Greece in 1978. It is a multigerm, non-O type, annual with prostrate growth habit. Testcross hybrids between the released lines and L33 were deficient in sucrose concentration, compared to commercial hybrids. Because of this it was decided to cross the above germplasm lines to L19. L19 is noted for its ability to produce hybrids with relatively high sugar concentrations. Its parentage includes the Polish variety 'Udyca'.

Fifty-six families (entries) were grown at Prosper, North Dakota in 1996. Each entry traced back to a single selfed  $F_1$  plant with the pedigree: L53cms / PI 546420 // L19. These families had an average sugar content of 13.3%; ranging from 8.4 to 15.9%. Recoverable sugar per ton of beets ranged from slightly below 100 to 298 lbs. per ton with an average of 237 lbs. per ton.

Individual roots of all entries were sampled for sucrose concentration. The mean of the 842 roots sampled was 14.56% (Table 1). Entry means of the 56 entries ranged from 10.7 to 17.1% sugar. Selection was based upon both family mean and individual root sucrose within a family. With two exceptions (C-85 and C-195) the selected families had means greater than 14.6%. Individual root sucrose concentrations ranged from 7.4 to 19.4% prior to selection. Selected roots ranged from 14.6 to 19.4% with a mean sugar percent of 16.1% or 1.6% higher than the unselected roots. 339 roots from 30 entries were selected for increase.

**Table 1. Progeny of crosses between Fargo "wild / cultivated" releases and L19.**  
**Sugar percentages are means of individual roots from lines selected for further**  
**evaluation, Prosper, North Dakota, 1996.**

Pedigree	Designation	Sugar		
		Before selection	Selected	roots
		%		no.
Y317 / L19	C-187	15.13	16.00	12
	C-188	15.87	16.68	15
	C-189	15.04	15.80	14
	C-191	15.13	15.71	10
	C-192	15.91	16.82	14
	C-193	16.09	16.61	11
	C-194	16.10	16.56	8
	C-195	14.43	15.28	11
	C-196	16.56	16.61	10
	C-197	17.08	17.20	10
	C-198	16.47	16.78	15
	C-199	16.67	17.40	10
	C-200	15.95	16.14	11
	C-201	15.39	16.04	11
	C-202	15.40	15.79	12
Mean	----	15.82	16.36	11.6
Y318 / L19	C-203	15.19	15.52	13
	C-204	16.24	16.24	10
	C-208	16.07	16.56	10
	C-211	14.24	15.50	9
Mean	----	15.44	15.96	10.5
Y322 / L19	C-40	15.06	16.01	11
	C-45	15.32	15.87	12
	C-62	15.28	15.95	13
	C-71	16.24	16.89	12
Mean	----	15.48	16.18	12.0
Y387 / L19	C-76	14.95	15.40	11
	C-78	16.76	17.17	10
	C-85	14.53	15.08	11
	C-89	15.31	15.53	12
	C-92	15.35	15.77	11
	C-121	14.95	15.87	10
	C-127	15.27	15.57	10
Mean	----	15.30	15.77	10.7
Mean all roots (number)		14.56 (842)	16.14 (339)	11.3



Each of the 30 selected entries will be maintained as an entity. Eight to 15 roots were selected from each entry for increase in the greenhouse (1997). Seed from plants within an entry (average of 11 plants / entry) will be bulked with the intention of testing each of the 30 entries (families) in replicated field tests in 1998. Seed was not available early enough for 1997 testing.

#### **CROSSES OF MISCELLANEOUS WILD *BETA* WITH SUGARBEET**

The sugarbeet parent in these crosses was a California line (3747) segregating for genetic male sterility. Crosses were made on male sterile segregates. In subsequent intercrosses, seed was harvested from male sterile segregates to maintain the sterility and insure intercrossing. After two cycles of random intercrossing all populations were grown in a space planted nursery and selected for root shape. Lines that performed well in testcrosses with L33cms in 1996, were increased and evaluated again in replicated trials in 1997 (Table 2). The low sugars observed in these trials was partially due to severe hail damaged in late August. Eleven of the 18 lines tested are being increased. These will be evaluated as lines again in 1998. Some will be examined in testcross hybrids and others used as parental material in the formation of new populations.

#### **RECENT INTRODUCTIONS TO THE BREEDING PROGRAM**

A population was formed by crossing a self incompatible sugarbeet line from California (R376-43) with thirty-seven wild *Beta* accessions from the United Kingdom, France, Ireland, Denmark, Belgium, and the Channel Islands. Ten plants from each wild population were crossed (as pollinators) individually to R376-43. Ten F<sub>1</sub> plants from each cross (100 plants) were intercrossed to produce the F<sub>2</sub> generation. Equal numbers of seeds from each F<sub>2</sub> plant were grown and intercrossed to produce the F<sub>3</sub> seed. These populations will undergo initial selection for root shape, etc., beginning in 1998.

All of the lines previously discussed in this report have wild germplasm in their parentage. In addition to the breeding efforts involving wild / cultivated crosses, we are also selecting for sugar and desirable agronomic traits in a broad based population (H-537) originally developed for high biomass production when there was heightened interest in obtaining fuel ethanol from beets.

Table 2. Yield of "cultivated / wild" sugarbeet, Fargo, ND, 1997.

Pedigree	Designation	Sugar	Root yield	Recoverable Sugar	
		%	T / A	lbs / T	lbs / A
3747 / B. maritima (Denmark)	C-19*	12.30	7.10	210	1538
	C-151	11.50	3.00	196	585
3747 / B. maritima (Belgium)	C-22*	12.30	7.50	208	1558
	C-153*	11.30	7.80	185	1365
3747 / B. maritima (Ireland)	C-27*	12.00	10.50	208	2200
	C-24*	10.90	10.50	180	1846
3747 / B. maritima (Middle East)	C-145*	11.20	11.50	189	2170
	C-156	10.20	9.20	165	1539
3747/B. Atriplicifolia	C-180*	12.10	11.40	205	2327
	C-165*	11.70	10.10	197	1933
	C-161	11.30	4.90	191	920
	C-141*	11.00	11.30	172	1804
	C-177	10.60	5.20	171	919
	C-174	10.60	5.50	168	967
	C-172	10.40	6.50	171	1113
3747 / B. macrocarpa	C-29*	10.60	10.20	176	1789
	C-159	10.50	10.10	168	1734
3474 / B. patula	C-143*	10.90	12.90	174	2206
F1010	----	14.20	9.10	253	2312
VDH - 66140	----	13.70	15.30	246	3755
ACH-192	----	12.50	15.70	210	3390
Mean	----	11.50	10.30	192	1997
LSD(0.10)	----	1.20	3.20	32	645

\* Indicates line was selected for further exaluation or as parental material for future crosses.

# A POLYMERASE CHAIN REACTION ASSAY BASED ON ACTIN GENE SEQUENCES FOR DISTINGUISHING SUGARBEET FUNGAL PATHOGENS.

## *Related Research*

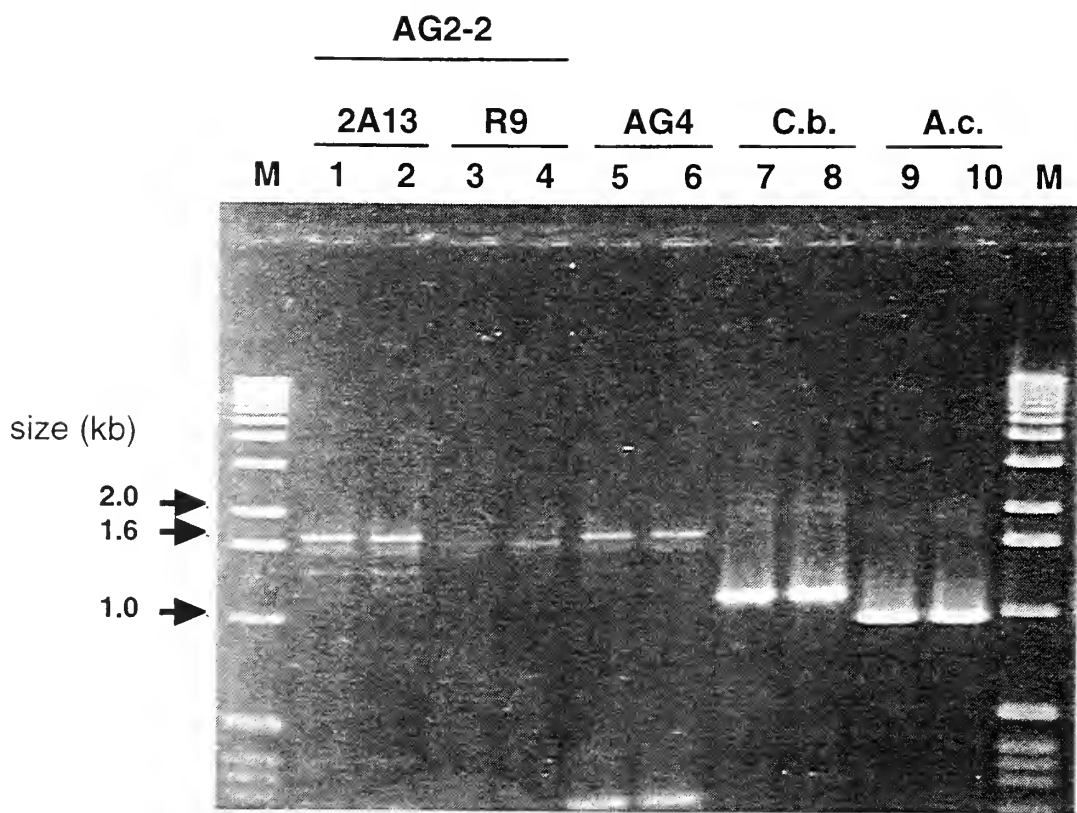
J. J. Weiland and J.L. Sundsbak

A number of soil fungi have the capability to incite disease in sugarbeet and these include *Rhizoctonia solani*, *Aphanomyces cochlioides*, *Pythium aphanidermatum*, *P. ultimum*, and *Fusarium oxysporium*. When seedling damping off or adult plant root rot occur, diagnosis of the causal agent of the disease can be a time-consuming process (days to weeks). Culture of the organisms from an infected area of the sugarbeet root can lead to the recovery of a plethora of fungi, many of which have colonized the infected tissue as saprophytes.

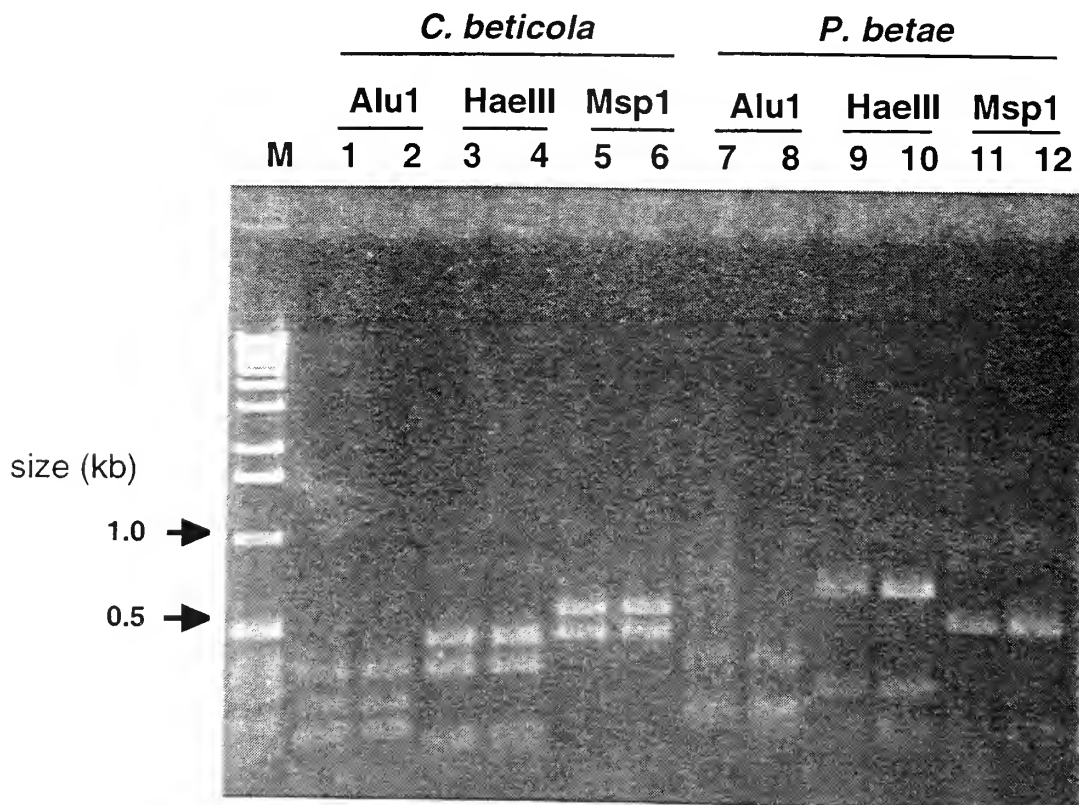
The polymerase chain reaction (PCR) is a DNA based technique for amplifying specific sequences from the genomes of organisms. PCR technology has impacted many fields of biology, including the area of disease diagnosis in both plants and animals. Diagnostics using the PCR are sensitive and highly discriminatory, since they target genome regions whose DNA sequences have diverged throughout evolution. PCR-based diagnostics also require little time for a result to be secured (within one to two days), making them attractive to high-throughput diagnostic laboratories.

The interests in our laboratory include the development of novel diagnostic tools for disease-causing fungi in sugarbeet, as well as the development of tools for investigating the biochemistry of sugarbeet pathogenesis by fungi. For this reason, we designed our PCR assay for the discrimination of sugarbeet fungal pathogens upon DNA sequences of the actin gene. Actin is a protein found in all eukaryotes and the gene coding for actin possesses sequence blocks of both high similarity, as well as of high divergence, across all eukaryotes. This facilitates the design of DNA "primers" that recognize the highly similar sequences in order to detect potential size variation in the actin gene that can be used to "fingerprint" and discriminate one sugarbeet pathogen from another. Actin is also a highly expressed gene and the cloning and re-engineering of actin gene sequences might provide a useful tool for gene transfer studies with sugarbeet fungal pathogens.

The use of actin gene sequences in the PCR for the discrimination of *R. solani*, *Cercospora beticola*, and *A. cochlioides* as shown in Figure 1. In some cases, little difference is observed in the size of the DNA products generated from two different organisms using gene-specific PCR. In such cases, digestion of the PCR products with restriction endonucleases often reveals polymorphisms that aid in discrimination of the organisms. This is illustrated by amplification of the actin gene sequences of *C. beticola* and *Phoma betae*, which are of similar size (data not shown), but possess polymorphisms that can be detected by digestion of the products with restriction enzymes (Figure 2). The results indicate that sufficient sequence divergence in the actin gene of sugarbeet fungal pathogens exists for the application of PCR detection and discrimination strategies. Future experiments will focus on the design of a specific PCR assay for each fungus based on the cloned actin gene sequences from *R. solani*, *A. cochlioides*, *P. aphanidermatum* and *P. ultimum*.



**Figure 1.** Amplification of DNA from the genomes of sugarbeet fungal pathogens with primers directed to actin gene sequences. The PCR reactions were performed in duplicate and products of the reactions were separated by electrophoresis through a 1% agarose gel in Tris-borate-EDTA buffer and stained with ethidium bromide. Two isolates of *R. solani* AG2-2 (2A13 and R9; lanes 1-4) are represented and one isolate of *R. solani* AG4 (lanes 5-6) is shown. Products from the amplification of DNA from *C. beticola* (lanes 7-8) and *A. cochlioides* are also shown (lanes 9-10). The sizes of the molecular weight standards (lane M) are shown to the left of the photograph.



**Figure 2.** Restriction enzyme digest of products amplified from the genomes of *C. beticola* and *P. betae* using primers directed to actin gene sequences. Products from duplicate PCR reactions were digested with the restriction endonucleases Alu1, HaeIII, and Msp1, followed by electrophoresis through a 1% agarose gel. Molecular weight markers (lane M) were co-electrophoresed as size standards.

# **SUGARBEET RESEARCH**

## **1997 REPORT**

### **Section E**

**Sugarbeet and Bean Research Unit  
Agricultural Research Service, USDA  
East Lansing, Michigan**

**Dr. J. W. Saunders, Research Geneticist, Plants  
Dr. J. M. Halloin, Plant Physiologists  
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# **1997 RHIZOCTONIA CROWN AND ROOT ROT NURSERY - COMMERCIAL VARIETY TEST, EAST LANSING, MICHIGAN.**

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The 1997 *Rhizoctonia* disease nursery, commercial test included 21 entries, with six replications. Plants were scored on a scale of 0 to 4, with 0 = no lesions found, 1 = up to 25% of the root covered with lesions, and 4 = 76 to 100% of the root covered with lesions. Dead or missing plants were scored as 4. The susceptible check was US H20, whereas FC 701/5 and FC 712 served as resistant checks.

A few of the entries appear to have resistance to *Rhizoctonia* that ranges from better than most, to very good. One entry, designated 96RR, scored as having disease resistance to *Rhizoctonia* superior to that of any other entry. This line is germplasm selected at East Lansing, MI, and is scheduled for release in 1998.

Table 1. Disease ratings of sugarbeet entries in the commercial *Rhizoctonia* crown and root rot test at East Lansing, MI, 1997.

#	Variety	Score	
13	ACH 503	3.92	A
18	HM 2732	3.90	A
10	ACH 319	3.90	A
11	B 5931	3.87	A
15	B 5216	3.85	A
12	HM E17	3.82	A
20	US H20	3.82	A
9	ACH 308	3.80	A
14	ACH 555	3.78	A
19	HM E26	3.78	A
17	B 5823	3.73	A
7	B K736	3.63	A
5	HM 2736	3.57	AB
4	HM 2733	3.52	AB
16	B 5713	3.50	AB
3	ACH 1353	3.20	BC
6	HM RH3	3.17	BC
8	SX 1217	2.92	C
1	FC 705/1	2.40	D
2	FC 712	2.23	D
21	96RR	1.70	E
L.S.D. (0.05)		0.38	

# ACCUMULATION OF OLIGOSACCHARIDES IN ASSOCIATION WITH A DEFENSE RESPONSE AROUND *RHIZOCTONIA* LESIONS ON SUGAR BEET TAP ROOTS.

BSDF Project 720

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**Background and objectives:** Recent evidence demonstrates that the oligosaccharides raffinose, stachyose and verbascose are important intermediates in the production of plant cell walls[1]. Sugar beet (*Beta vulgaris*) tap roots infected by *Rhizoctonia solani* AG 2-2 develop disease lesions at warm temperatures (more than 25°C); lesion development ceases and the tissue surrounding these lesions undergoes a defense reaction at cool temperatures (less than 15°C), accompanied by production of o-dihydroxy phenolic compounds in the tissue immediately subtending the disease lesion[2]. Experiments were done to determine if accumulation of oligosaccharides, indicative of new cell wall synthesis, occurs in sugar beets in association with the observed defense response.

**Materials and methods:** Sugar beets were planted in a plant disease nursery in East Lansing, MI, USA, and inoculated with *R. solani* in mid-July by dispensing into their crowns millet on which the fungus had been grown. Healthy plants were grown in a nearby field. Plants were harvested in late August, and were tested, individually, for the presence of o-dihydroxy phenolic compounds[2]. Tissue samples were dissected from several locations on individual tap roots, frozen, freeze-dried, and stored at -20°C awaiting assay of oligosaccharide contents. Soluble oligosaccharides were extracted with water (15 min., 0°C, with sonication) and were separated and quantitated by high pH anion exchange chromatography, with pulsed amperometric detection.

**Results and conclusions:** Phenolic compounds indicative of the defense response were not detected in any of the healthy tap roots used, but were found in tissues subtending disease lesions on all diseased roots. Small amounts of the three oligosaccharides, raffinose, stachyose and verbascose were present within healthy sugarbeet tap roots. Slightly higher concentrations of the compounds were found in growing vascular ring tissues at or subtending the root surface than in the developed tissues of the root interior. Within the diseased roots, low concentrations of the oligosaccharides were found within rotted tissue and in interior tissues, well-separated from disease lesions; comparatively high concentrations were found in tissues immediately subtending disease lesions. Comparison of concentrations of the oligosaccharides from healthy and diseased roots showed no differences between rotted tissue and healthy surface tissue, and between interior tissues of rotted and healthy roots. However, the tissue immediately subtending disease lesions contained concentrations of the oligosaccharides at least twice those of other tissues. Increased concentrations of oligosaccharides within diseased root tissues exhibiting a defense response suggests that renewed cell wall synthesis involving these compounds is an important part of defense. Additional research is needed to establish the dynamics and roles of these materials in the healing response. This is the first report of accumulation of these oligosaccharides as part of a disease resistance response; their involvement in disease resistance may be more wide spread.

**References:** 1.Murray AK 1998. United States Patent No. 5,710,047;2.Halloin JM 1994. Plant Science 99, 223-228.

# THE EFFECT OF SEED DENSITY ON SEED PERFORMANCE AND YIELD OF SUGARBEETS

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Seedling vigor is a major problem in sugarbeet production. Prior studies with sugarbeets and other crops have demonstrated a positive correlation between seed density and seedling emergence and vigor. Currently, sugarbeet seeds are density graded on a gravity table to eliminate a substantial portion of the seeds with low density. This experiment was done to determine if the performance of seed lots subjected to separation on a gravity table could be further enhanced by more rigorous density grading.

## Methods:

Seeds of two commercial varieties, American Crystal 185 and 319, were first gravity graded on a gravity table. The "dense seeds" from this selection were used throughout this experiment. Seeds given no further selection, but soaked for five minutes in water were classed as nonselected (NS). A second portion of these seeds were immersed in water. Those seeds that floated on the water were classified as low density (LD). Seeds that sank in water were collected and immersed in a sucrose solution with a density of 1.075 (200 g sucrose per L). Those seeds that floated on the sucrose solution were classified as medium density (MD), and those that sank in the sucrose solution were classified as high density. All seeds were rinsed with water following separation, and were air-dried for several days before use.

Numbers of seeds separated into each density group were determined. Seed samples (in quadruplicate) were counted into groups of 200 seeds and weighed to determine seed weights. Seeds were placed in rolled germination towels (4 towels, 50 seeds per towel) and incubated at 22°C for germination. Numbers of seeds germinated were counted 3, 6, and 9 days after the start of germination. Data obtained were used to determine germination percentages and speed of germination (germination index).

Samples of 200 seeds were planted in field plots at the Bean and Beet Research farm, Saginaw, MI, April 25, 1997 in 1-row plots, 25 feet long. Six replications of each seed group were planted in randomized, complete blocks. Final stand counts were made on 20 feet of plot row on June 1, 1997. Plants were then thinned to approximately 8-inch spacing and grown until harvest in early October, 1997. Plot yields were determined at harvest, and juice samples were assayed by Michigan Sugar Company.

## Results:

Results of experiments are summarized in Table 1. Statistically significant differences among seed samples were found for all seed- related parameters (weight, germination percentage, germination index, and stand). The most dense seeds were the heaviest, had the highest germination percentages, germinated more quickly, and gave the highest stands in the field. No statistically significant differences were found among seed samples for yield or sugar quality parameters.

**Discussion:**

Sugarbeet seeds, even highly polished ones, are highly irregular in shape. This irregularity, together with the high numbers of seeds flowing across a gravity table under present practice, causes the seeds to interfere with each other during separation on a gravity table. The results of this study demonstrate that significant improvement in seed quality can be achieved through improved gravity grading. However, using present methods (the gravity table) such improvement could likely be achieved only by slower flow of seeds through the system (less seeds on the table at any moment) and/or through a much more restrictive cut (higher density, smaller fraction of seeds acceptable) on seed acceptability. Either of these practices would likely provide large increases in the cost of planting seeds.

Although differences in yield among the selected seed groups were not statistically significant, there was a definite tendency for denser seeds to provide higher yield. The design of the experiment, particularly thinning to stand, seems likely to have diminished and benefits arising from improved density grading. Experiments involving planting to stand would likely be more appropriate for demonstrating such benefits. Only then could the economic benefits of improved seed selection be determined.

Table 1. The effect of seed density selection on seed performance and yield of sugarbeets.

Variety	Sample <sup>a</sup>	% of Seeds	Seed Weight (g/200)	Germination % Index <sup>b</sup>	Stand (Seedlings per 20 ft.)	Yield Per Acre Tons	RWS (lbs)	RWST (lbs)	% (sucrose)	CJP %
ACH 185	NS	100.0	2.06	71	0.51	115	6170	248	17.9	92.1
	LD	25.5	1.92	40	0.31	74	5770	251	17.8	92.8
	MD	39.5	2.05	65	0.45	98	5840	251	17.9	92.6
	HD	35.0	2.11	77	0.58	108	5770	253	17.9	92.9
	<b>L.S.D. (0.05)</b>	-	<b>0.04</b>	<b>13</b>	<b>0.11</b>	<b>14</b>	<b>n.s.</b>	<b>n.s.</b>	<b>n.s.</b>	<b>n.s.</b>
ACH 319	NS	100.0	1.93	69	0.56	91	5690	250	17.8	92.8
	LD	29.0	1.79	53	0.43	78	5800	251	17.9	92.6
	MD	37.8	1.92	67	0.51	100	6040	248	17.7	92.6
	HD	33.2	1.98	81	0.69	101	6250	248	17.6	92.9
	<b>L.S.D. (0.05)</b>	-	<b>0.03</b>	<b>9</b>	<b>0.11</b>	<b>11</b>	<b>n.s.</b>	<b>n.s.</b>	<b>n.s.</b>	<b>n.s.</b>
Combined	NS	100.0	1.99	70	0.53	103	5930	249	17.8	92.5
	LD	27.2	1.85	46	0.37	76	5790	251	17.8	92.8
	MD	38.7	1.99	66	0.48	99	5940	250	17.8	92.6
	HD	34.1	2.04	79	0.63	105	6010	250	17.8	92.9
	<b>L.S.D. (0.05)</b>	-	<b>0.07</b>	<b>8</b>	<b>0.08</b>	<b>9</b>	<b>n.s.</b>	<b>n.s.</b>	<b>n.s.</b>	<b>n.s.</b>

<sup>a</sup>Seed Samples: NS = non selected, LD = low density (float on water), MD = medium density (sink in water, float on 1.075 density sucrose solution), HD = high density (sink in 1.075 density sucrose solution).

<sup>b</sup>Germination index: germination, weighted for speed of germination.

# EVALUATION OF RESISTANCE OF SUGARBEETS TO SEEDLING DISEASE CAUSED BY *APHANOMYCES COCHLIOIDES*: A DISEASE SCORING SYSTEM AND DISCRIMINATION BETWEEN RESISTANT AND SUSCEPTIBLE VARIETIES IN A ROLLED TOWEL SYSTEM.

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Previously, we reported evaluation of the effect of temperature and concentration of *Aphanomyces cochlioides* zoospore inoculum on rate and severity of *Aphanomyces* seedling disease development in seedlings in rolled germination papers, using a sugarbeet variety with putatively moderate resistance to the disease. Disease developed slowly at 15°C, rapidly at 30°C, and was intermediate in rate of development at intermediate temperatures. Inoculum concentration also influenced disease development, with seedlings inoculated with  $10^4$  zoospores  $\times$  ml<sup>-1</sup> developing disease more rapidly than those inoculated with  $10^3$  zoospores  $\times$  ml<sup>-1</sup>.

The rating system used previously to evaluate disease development in seedlings was based on numerical scores from 0 (= no disease) to 4 (= >75% of seedling diseased). We observed that there were occasional seedlings within noninoculated control groups that exhibited symptoms similar to those of inoculated seedlings. However, these symptoms seldom involved more than 25% of the seedling, and did not expand with time. *Aphanomyces* lesions typically expand to encompass the entire seedling root within 2 - 3 days. Statistical analysis showed that when the highest disease categories in the rating system (2,3 and 4) were eliminated, the power of the test was little reduced. Thus, the disease rating system was simplified to include only two categories, 0 (0 - 25% of seedling diseased) and 1 (>25% of seedling diseased).

Experiments were done to evaluate rate of disease development in seedlings of two hybrid varieties, USH20, a moderately resistant hybrid, and one supplied by Betaseed (Shokapee, MN) designated "Canadian susceptible hybrid #3". This latter variety was rated as highly susceptible to *A. cochlioides* in Betaseed nursery tests. Seeds were germinated for 4 days at 22°C, in rolled germination towels. Seedlings then were removed from the towels, immersed for 10 minutes in a suspension containing  $10^3$  zoospores  $\times$  ml<sup>-1</sup>, and placed on newly prepared germination towels. They then were placed under continuous light in a growth chamber at 25°C, and disease development was monitored daily for a week.

Disease was not observed until 2 - 3 days following inoculation, and increased throughout the observation period. Disease development was most rapid in the "susceptible hybrid", and included nearly all seedlings after 6 days of incubation. The slower development of disease in seedlings of the "resistant hybrid" enabled statistically significant discrimination between the two hybrids at 4 - 5 days following inoculation. Differences between the hybrids in disease frequency (score = 1) were less pronounced 6 days following inoculation, and all seedlings eventually succumbed to the pathogen.

These results indicate that resistance to *A. cochlioides* expressed by hybrid USH20 does not impart immunity to the pathogen; rather, it reduces the rate of disease development. We anticipate that the methods used in this study can be developed into an effective assay for evaluating the resistance of sugarbeet varieties to *A. cochlioides*.

# EVALUATION OF SMOOTH ROOT BREEDING LINES SEGREGATING FOR RHIZOMANIA RESISTANCE

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In 1993 crosses between rhizomania resistant germplasm lines R276 and R280 (near isolines of C82 and C80, respectively) obtained from the Salinas, CA USDA-ARS breeding program and a number of high sugar, smooth rooted East Lansing breeding lines were initiated by Dr. Clair Theurer (now retired). Smooth root selections from the initial hybrid materials were interpollinated over the winter of 1994-1995, keeping pedigrees separate based on the original rhizomania resistant source. In 1995, smooth root selections were again performed and interpollinated. Remnant seed from these crosses, designated with the prefix 94RM and 96RM, were planted in 1997 at the Saginaw Valley Bean and Beet Farm, MI for agronomic testing in two row, six replication 30' plots (Test 973BB). Where sufficient seed was available, disease testing was performed in 1997 at East Lansing for *Rhizoctonia* root rot (Test 978R) and *Cercospora* leaf spot (Test 974L) reactions as well as for rhizomania resistance in Salinas, CA.

Twenty-six RM lines were evaluated along with two commercial checks, one smooth root release (SR87) and a prospective East Lansing *Rhizoctonia* resistant release (designated 96RR). Recoverable white sugar per acre (RWSA) values were not significantly different from one another with the exception of 96RR. Percent sucrose showed a wide range of significant differences and the relatively high but not significantly different yield of RM lines over the commercial entries apparently compensated for their lower sucrose in RWSA scores. Clear juice purity was somewhat reduced in RM lines relative to the checks. On average, the root suture was less pronounced in the RM lines relative to the commercial checks, with some entries approaching the level of smooth rootedness of SR87. RM lines showed similar levels of resistance to *Rhizoctonia* root rot and *Cercospora* leaf spot (scored at East Lansing) to USH20. RM lines were expected to be segregating for the single gene for rhizomania resistance. The level of resistance detected in the tested entries was variable but consistent with expectations. The more resistant lines have been selected in Salinas and are currently being intercrossed.

Summary of tests 973BB, 974L and 978R with lines segregating for rhizomania resistance

Entry	RWSA	RWST	T/A	Suc %	CJP %	Sprangle	Suture	Rhizoc	Rhizom	LS
ACH185	5935 A	244.1 A	24.32 A	17.49 A	92.48 AB	1.50 BCD	2.38 AB	-	-	-
HME17	6041 A	243.7 A	24.87 A	17.20 A	93.21 A	1.25 CD	2.50 A	-	-	-
96RM15-03	5562 A	216.5 B	25.79 A	15.64 BCD	92.49 AB	1.50 BCD	2.13 ABC	3.32 A	3.3	7.00 ABC
96RM11-04	5344 A	214.8 BC	24.87 A	15.65 BCD	92.13 BCD	1.00 D	2.38 AB	-	-	-
94RM3-3	5555 A	213.3 BCD	26.03 A	15.51 BCDEF	92.26 BC	1.50 BCD	2.25 ABC	-	-	-
94RM4-2	5431 A	212.9 BCD	25.50 A	15.76 B	91.45 CDE	1.25 CD	2.38 AB	3.55 A	3.8	6.00 BCD
96RM14-01	5736 A	212.4 BCDE	27.00 A	15.58 BCDE	91.85 BCDE	2.00 ABCD	2.25 ABC	-	3.3	-
96RM13-02	5173 A	212.4 BCD	24.34 A	15.64 BCD	91.71 BCDE	2.50 AB	2.00 BCD	3.36 A	3.4	8.33 A
96RM10-01	5042 A	211.7 BCDEF	23.82 A	15.76 B	91.22 DE	1.75 ABCD	1.88 CD	-	-	-
96RM14-02	5513 A	211.3 BCDEF	26.12 A	15.58 BCDE	91.64 BCDE	2.50 AB	2.13 ABC	3.58 A	3.2	7.00 ABC
94RM3-7	5703 A	210.8 BCDEFG	27.04 A	15.35 BCDEFGHI	92.24 BC	1.50 BCD	2.13 ABC	-	-	-
96RR	3665 B	210.6 BCDEFG	17.38 B	15.69 BCD	91.21 DE	1.00 D	2.50 A	2.34 B	4.4	4.67 D
94RM2-2	5269 A	210.4 BCDEFGH	25.09 A	15.74 BC	91.02 E	2.00 ABCD	1.88 CD	-	4.0	-
94RM13-2	5184 A	209.4 BCDEFGH	24.71 A	15.49 BCDEF	91.55 BCDE	1.50 BCD	2.25 ABC	3.48 A	-	7.67 AB
96RM10-06	5042 A	208.9 BCDEFGH	24.12 A	15.38 BCDEFG	91.75 BCDE	1.00 D	2.13 ABC	3.67 A	-	6.00 BCD
96RM11-01	5308 A	208.6 BCDEFGH	25.44 A	15.36 BCDEFGH	91.76 BCDE	2.00 ABCD	2.13 BCD	-	-	-
96RM15-01	5634 A	208.0 BCDEFGH	27.09 A	15.19 DEFGH	92.13 BCD	2.50 AB	1.88 CD	-	-	-
94RM10-6	5414 A	207.4 BCDEFGH	26.12 A	15.38 BCDEFG	91.46 CDE	1.50 BCD	2.13 ABC	-	-	-
96RM15-02	5737 A	207.2 BCDEFGH	27.70 A	15.10 EFGH	92.25 BC	1.75 ABCD	2.00 BCD	-	3.4	-
96RM10-05	5225 A	206.2 BCDEFGH	25.33 A	15.21 DEFGH	91.72 BCDE	1.75 ABCD	1.88 CD	-	3.6	-
96RM13-01	5791 A	205.6 CDEFGH	28.17 A	15.24 DEFGH	91.51 BCDE	1.75 ABCD	2.13 ABC	-	3.6	-
96RM10-02	5695 A	204.6 CDEFGH	27.48 A	15.20 DEFGH	91.41 CDE	2.00 ABCD	1.88 CD	-	3.3	-
94RM8-3	5277 A	204.0 DEFGH	25.87 A	15.26 CDEFGH	91.13 DE	1.75 ABCD	1.88 CD	3.42 A	-	6.67 ABC
96RM10-04	5830 A	203.1 DEFGH	28.74 A	15.04 FGH	91.59 BCDE	2.25 ABC	1.88 CD	-	-	-
94RM3-8	5358 A	201.7 EFGH	26.54 A	14.86 I	91.86 BCDE	2.25 ABC	1.88 CD	3.75 A	-	5.33 CD
SR87	5309 A	201.6 FGH	26.35 A	14.87 H	91.80 BCDE	2.75 A	1.63 D	-	-	-
94RM12	5572 A	201.1 FGH	27.73 A	15.02 FGH	91.23 DE	1.25 CD	2.25 ABC	-	-	-
96RM11-02	4928 A	200.4 GH	24.60 A	15.03 FGH	91.06 E	2.25 ABC	1.88 CD	-	3.4	-
96RM12-00	5406 A	199.9 H	27.03 A	14.93 GH	91.29 CDE	1.75 ABCD	2.13 ABC	3.27 A	4.2	6.67 ABC
96RM11-03	5116 A	199.3 I	25.69 A	14.96 GH	91.05 E	2.25 ABC	1.63 D	3.55 A	3.8	6.33 BCD
USH20	-	-	-	-	-	-	-	3.37 A	-	7.00 ABC
6869	Rhizomania check line from Salinas rhizomania Test 5697: mean = 3.7, CV % = 12.7, LSD (0.05) = 0.5									



## EVALUATION OF FIELD EMERGENCE FOR FIVE VARIETIES

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Five entries were chosen for a close examination of seedling emergence and stand establishment under field conditions. These varieties were chosen on the basis of past experience gleaned from variety evaluations provided by Monitor Sugar Co. and Michigan Sugar Co. tests over the past five years. Varieties were chosen on the basis of their real or perceived ability to produce a consistent range of final stand counts over two or more of these five years. In these cases, USH20 had the highest counts, followed by HME17 and ACH185. B5931 showed differences between years, but generally approximated ACH185. The seedlot of USH23 used here was produced in the early 1980's and its germination was known to be compromised. It was used as a low stand check variety.

Single row, eight replication 30' plots of 100 seed each were sown April 25, 1997. The center 20' was marked and counted with a maximum of 67 seeds per plot expected. Some varieties, such as USH20 and to a lesser extent ACH 185, have been shown in the laboratory to contain a small percentage of double seed per fruit (ca. 2%). The plots in this experiment (Test 971BB) were not thinned.

Conditions were nearly ideal in 1997 for seedling emergence and stand establishment, a feature that perhaps masked some differences that would be evident in more stressful environments. However, USH20 was consistently the best performer in emergence, followed by HME17, ACH185, B5931 and USH23 respectively. Little deviation was seen in this pattern except counts at day 17 and day 46 where HME17 had a slight, but non-significant, edge over USH20.

All varieties except USH23 had reached 50% emergence by the 17th day, USH20 and B5931 slightly earlier than ACH185 and HME17 by extrapolation. USH23 reached 50% emergence between the 19th and 21st days. Future studies should target the critical initial phase from zero to 50% germination, however this apparently occurs during a short window of opportunity. Maximal emergence occurred at day 24 for USH20, ACH185 and B5931 and at day 28 for HME17 and USH23. However, the difference between HME17 at days 24 and 28 is not significant. Stands were relatively stable until between day 39 and 46 where a significant drop occurred after a warm, dry spell. A significant drop also occurred between the final stand count and just prior to harvest for unknown reasons. Harvest stands (not harvested beets) ranged from 42% to 50% of maximal stands. Interestingly, the overall pattern of stand at harvest was evident by day 19, although the numbers of beets were different at these times.

In general, it would appear that varietal and/or seedlot differences exist in the ability to generate and maintain stands over the growing season. Also, it appears that these differences are manifest early in the season and persist throughout the growing season, at least under favorable growing conditions as experienced in 1997. Delayed emergence, as shown by USH23, exacts a substantial yield penalty, perhaps 500 pounds of recoverable sugar per acre in this case assuming its RWSA is equivalent with USH20, a conservative assumption. Otherwise, there appears to be few if any correlations of emergence data with the harvested agronomic data, at least with this preliminary data set.

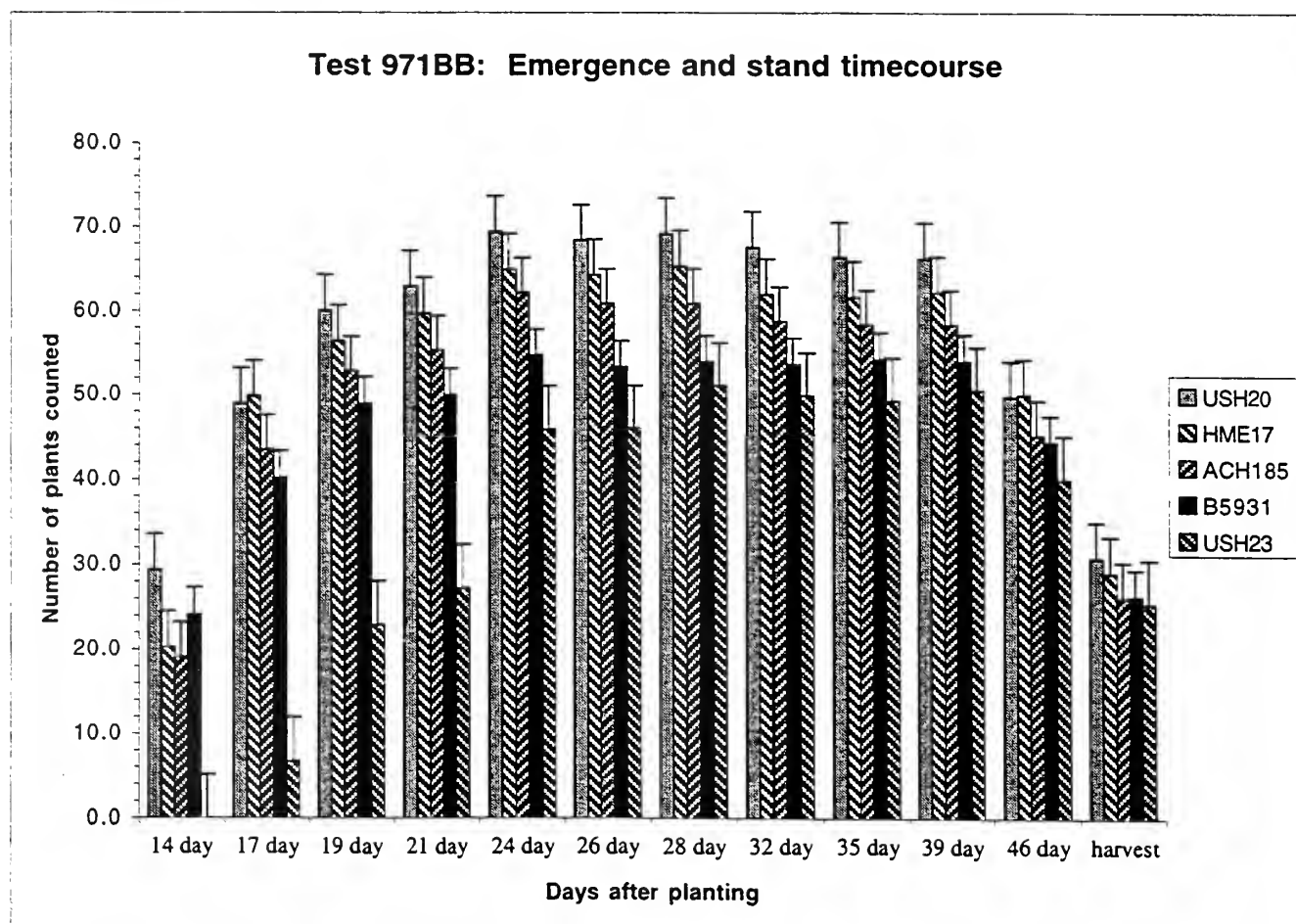
Test 971BB: Agronomic evaluations.

Entry	RWSA		RWST		T/A		SUC %		CJP %		Canopy	
USH20	2982	AB	216.1	B	13.8	AB	15.66	B	92.37	AB	1.63	B
HME17	3011	AB	235.8	A	12.8	BC	16.84	A	92.75	A	2.38	A
ACH185	2952	B	226.4	A	13.0	ABC	16.53	A	91.87	B	1.75	B
B5931	3414	A	232.4	A	14.7	A	16.58	A	92.85	A	1.25	B
USH23	2420	C	206.0	C	11.6	C	15.00	C	92.36	AB	1.75	B

Test 971BB: Emergence evaluations.

Entry	14 day	17 day	19 day	21 day	24 day	26 day	28 day	32 day	35 day	39 day	46 day	harvest
USH20	29.4	48.9	60.0	62.9	69.4	68.4	69.1	67.6	66.4	66.3	49.8	30.8
HME17	20.3	49.8	56.4	59.6	64.9	64.3	65.3	62.0	61.6	62.3	50.0	29.0
ACH185	19.1	43.4	52.8	55.3	62.1	60.9	60.9	58.8	58.4	58.4	45.1	26.1
B5931	24.1	40.1	48.9	49.9	54.6	53.3	53.9	53.6	54.3	54.0	44.3	26.3
USH23	0.0	6.8	22.9	27.1	45.8	45.9	51.0	49.9	49.3	50.5	39.9	25.4
<b>Mean</b>	18.6	37.8	48.2	51.0	59.4	58.5	60.0	58.4	58.0	58.2	45.8	27.5
LSD (0.05)	3.9	4.1	4.2	4.4	3.8	3.9	3.9	3.6	3.7	3.5	3.2	1.8
CV %	29.1	15.0	12.2	12.0	8.9	9.4	9.1	8.6	8.8	8.3	9.7	9.2
F value*	34.0	79.5	50.3	42.9	25.1	21.5	15.4	15.5	13.4	13.5	7.2	6.5

\* all significant at 0.001 level



## FIELD EVALUATION OF A RANGE OF *Beta vulgaris* GERMPLASM

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*Beta vulgaris* L. is a diverse species with its major economic and nutritional importance from sugar beet as a source of sucrose in human diets. Besides sugar beet, *Beta vulgaris* is also grown as a table vegetable (e.g. red or table beet), a leafy vegetable (e.g. Swiss chard) and as a source of animal feed (e.g. fodder beet). Each of these types probably shares an ancestor in the wild beets found along the coasts of Northern Europe and the Mediterranean Sea (e.g. the *maritima* types). The wild beets show a much greater range of variation than do the cultivated crops. Each of the wild and cultivated types has some potential to contribute genes of economic importance to sugar beet and in some cases this potential has been realized. For example, resistance to *Cercospora* leaf spot in sugar beet can be traced back to hybridizations with resistant wild beets performed in Italy during the early part of this century. Similarly, fodder beet was hybridized with sugar beet for the purpose of creating an efficient renewable source energy through alcohol fuel production. Resistance to rhizomania and the beet cyst nematode also trace back to wild beets and related species.

The purpose of these experiments was to observe the range of variation across the species. Ancillary goals were to observe and evaluate methods and procedures, assess agronomic characteristics and seed viability in historically important germplasm releases from East Lansing seed stocks, examine germplasm carrying genes that will allow better understanding of agronomically-important genes and their location in the genome and fold these into the USDA sugar beet breeding and genetics program, and evaluate some current commercial varieties and recent USDA germplasm releases for comparison.

Test 97OBS: Single row, 30' plots of 60 accessions were planted. Eighteen of these had no or low germination / field emergence. In general, Swiss chard was exceptional in its emergence and vigor and showed luxuriant top growth over the entire season. Its roots were extremely sprangled (i.e. had many side roots, fangy). Similarly, stands of red beets were high but the plants were not as vigorous as Swiss chard and their canopy was very thin. Wide differences were seen with sugar beet and fodder beet. These differences are most likely the result of the age of the seed planted. Seed storage conditions at East Lansing have been less than ideal, a deficiency that is being addressed through construction of a controlled temperature and humidity room in East Lansing. The wild beets did not perform well with the exception of an annual variety. Germination of sugar beet mutants was also disappointing, however some were recovered and saved for seed increase. Variation in leaf shape, root size and shape, plant architecture, canopy, color and the distribution of color, vigor and the attractiveness to deer grazing were noted among varieties. Some inconsistencies in variety identification were noted.

Test 97OBS2: Agronomic information on East Lansing USDA germplasm releases over the history of the program (at least those where seed was readily available) were determined from single replication, two row 30' plots. In addition, 10 breeding lines from the USDA program in Salinas, CA (courtesy of Dr. Robert Lewellen) were included. The Salinas materials represent a very different breeding history than those from East Lansing and other USDA breeding stations. Notably, the Salinas materials are a source of resistance to the fungally-vectored rhizomania virus. Additionally,

unlike the East Lansing materials which have generally followed a population improvement breeding strategy, some of the Salinas lines are self-fertile segregating with a single Mendelian gene for male sterility. This is an advantage in determining the inheritance of agronomic traits and will be important in applying molecular tools to sugar beet breeding. Stand establishment of older East Lansing releases was generally low or nil, for reasons described above. Where stands were adequate, agronomic data was collected and is presented in tabular form. However, insufficient seed was available for each of these lines and replicated trials were not possible. Selections were made from some of these lines for further work.

Test 975BB: As a final comparison of sugar beet germplasm, 10 commercial varieties, two US hybrids, three smooth-root germplasm releases and one prospective release were evaluated in two row, six replicate 30' plots. Stands were very good, with the exception of USH23 which was slow to emerge.

Overall, the wide range in morphological variation in *Beta vulgaris* was encouraging as, from a breeding perspective, these approximate the limits that sugar beet morphology could assume by hybridization and selection in a breeding program. Further, the range of agronomic characters was also deemed to be relatively high but the limits of these relative to the entire germplasm base can not be assessed from these data. It is clear that sufficient variability exists for improvement on a number of fronts, including the bottom line recoverable white sugar per acre. What is lacking are reliable estimates of the genetic contribution of these characteristics, without which more precise and efficient sugar beet germplasm enhancement can not be achieved. Selections taken from these tests should help in furthering understanding of these genetic components, their inheritance and expression. With this information it becomes more likely to recover an improved sugar beet type from hybridization with distantly related but potentially useful species in a reasonable period of time.

# TEST 97OBS: Single row tests without agronomic data

<u>Entry</u>	<u>Type</u>	<u>1997 Stand</u>	<u>Features</u>
SP6822	Beltsville release	high	MM, LS, Aph, Parent line
SP7622	Beltsville release	intermediate	MM, LS, Aph, Parent line
SP85320-0	Beltsville release	intermediate	mm, Bvm:cms, LS, Aph
SP85320-01	Beltsville release	intermediate	mm, O, LS, Aph
SP85576-0	Beltsville release	high	mm, O, LS, Aph
SP85576-01	Beltsville release	high	mm, cms, LS, Aph
SP85700	Beltsville release	high	MM, SR, LS, Aph
SP8580-5 sib	Beltsville release	high	(sic) SP8530?
7645	Bergen Smooth Root	intermediate	SR
M101	Bergen Smooth Root	low	SR
M94	Bergen Smooth Root	low	SR
F1010	Fargo release	high	MM, High sugar
Blanca	fodder beet	intermediate	
FB33	fodder beet	none	
Rota	fodder beet	low	
Wintergold	fodder beet	high	
FC607-0	Fort Collins release	intermediate	mm, O, LS
FC607-01	Fort Collins release	intermediate	mm, cms, LS
A93-9	High Crown - World Polycross	high	
28M3	high sugar line	intermediate	
46I-1	high sugar line	intermediate	
AH27	high sugar line	high	
L19	high sugar line	low	
A93-7	High Yield - World Polycross	high	
L50	Logan inbred release	low	
A90-MM	Mescan's round sugar beet	high	
A7408	mutant - candy stripe	none	
4A22	mutant - chlorina	intermediate	
86M1	mutant - chlorina	none	
86M3	mutant - feather leaf	none	
88M9	mutant - ruffled petiole	intermediate	
86M4	mutant - russet root?	none	
87M8	mutant - russet root?	intermediate	
86M6	mutant - virescent	none	
MO573-2	mutant - virescent	intermediate	
86M7	mutant - yellow root?	none	
86M5	off type - trout leaf	none	
4E26-16	off-type - dark trout	intermediate	
4E57-4	off-type - dark trout	intermediate	
M822-7	off-type - light trout	intermediate	
Big Red	red beet variety	high	
RubY Queen	red beet variety	high	
Red	Red sugar beet	high	
A93-8	Round Beet - World Polycross	high	
SLC129cms	Salt Lake City release	low	Parent line
Fordhook Giant	Swiss chard variety	high	
Lucullus SC	Swiss chard variety	high	
Rhubarb SC	Swiss chard variety	high	
8326	wild beet	none	
AI32	wild beet	low	
m8126	wild beet (sic)	high	
O911	wild beet	none	

O912	wild beet	none
PI180410	wild beet	high
SL8328	wild beet	low
W357B	Wisconsin red beet release	intermediate
W364A	Wisconsin red beet release	intermediate
Yellow	Yellow sugar beet (chlorina)	high

# **Test 97OBS2: Two row observation plots with agronomic data**

<u>Entry</u>	<u>Type</u>	<u>1997 Stand</u>	<u>Features</u>
SP85576-01	Beltsville release	high	mm, cms, LS, Aph
SP6822	Beltsville release	high	MM, LS, Aph, Parent line
EL38	East Lansing release	low	mm, O
EL38 cms	East Lansing release	none	mm, cms, yield
EL40	East Lansing release	none	MM, LS, Aph, Parent line
EL41	East Lansing release	none	MM, LS, Aph
EL42	East Lansing release	none	MM, Rzt, LS, Aph ( <i>fr</i> 6822)
EL43	East Lansing release	none	MM, Rzt, LS, Aph ( <i>fr</i> 6822)
EL44	East Lansing release	none	mm, O, CT
EL44 cms	East Lansing release	none	mm, O, CT, cms
EL45/2	East Lansing release	none	mm, O, CT, Phoma?
EL46	East Lansing release	low	TLWR, Aph, MM
EL48	East Lansing release	high	mm, Aph, LS, Rzt, mm, nO
EL49	East Lansing release	intermediate	SR, MM
EL50	East Lansing release	low	LS, High sugar, mm
BLANCA	fodder beet	low	
L19/2	Logan release	high	Selection of High sucrose L19
USH20	Michigan hybrid	high	(EL44cms x EL45) x SP6822
USH23	Michigan hybrid	intermediate	(SP6926-01 x EL45) x EL40
6869	Salinas breeding line	intermediate	mm, Sf, A-:aa, Rzm
6931	Salinas breeding line	high	MM, Sf, A-:aa, Rzm
R522	Salinas breeding line	high	MM, OP,Ss, Rzm, 50%Bvm
R609	Salinas breeding line	high	MM, Sf, A-:aa, Rzm, 25%BvmLS
R626	Salinas breeding line	high	MM, OP,Ss, Rzm, 50%Bvm
R639	Salinas breeding line	high	MM, OP,Ss, Rzm
R681	Salinas breeding line	high	MM, OP,Ss, Rzm
Y668	Salinas breeding line	high	MM, OP,Ss, Rzm
Y669	Salinas breeding line	high	MM, OP,Ss, Rzm
Z430	Salinas breeding line	high	MM, Sf, A-:aa, Rzm, 50% Z-sugar

## Abbreviations:

A-:aa - Mendelian male sterility segregating  
Aph - Aphanomyces tolerant  
Bvm - wild maritima germplasm present  
cms - cytoplasmic male sterile  
CT - curly top virus resistant  
*fr* - from  
LS - Leaf spot resistant  
mm - monogerm seed  
MM - multigerm seed

O - O-type cms maintainer line  
OP - open pollinated (out-crossed)  
Rzm - rhizomania resistant  
Rzt - Rhizoctonia resistant  
Sf - self fertile  
SR - smooth root  
Ss - self sterile  
TLWR - tap root:leaf weight ratio  
Z-sugar - Polish high sugar

1997 Stand: Visual rating of field establishment (high =no gaps, intermediate =one or more 3' gaps, low = <10 plants per 30' row, none = no germination).

Test 97OBS2: East Lansing releases and Salinas breeding lines. Two row, single replication observation plots.

<u>Entry</u>	<u>RWSA</u>	<u>RWST</u>	<u>T/A</u>	<u>%Suc</u>	<u>%CJP</u>	<u>Sprangle</u>	<u>Suture</u>
EL48	4820.6	178.7	27.0	13.7	90.6	3	3
EL49	3481.5	165.7	21.0	13.2	89.2	3	1
EL50	3562.2	202.4	17.6	15.0	91.7	1	1
US H20	4673.5	228.8	20.4	16.2	93.3	3	3
US H23	5566.0	215.5	25.8	15.7	92.2	3	3
SP576-01	4156.9	215.7	19.3	15.5	92.7	2	3
SP6822	5831.7	213.1	27.4	15.9	91.2	3	2
L19/2	5721.6	255.9	22.4	18.4	92.3	3	3
R639	4985.7	179.6	27.8	14.1	89.5	2	2
R681	6095.2	216.6	28.1	15.9	91.8	3	2
Y668	6371.1	204.1	31.2	15.1	91.6	3	2
Y669	5731.1	212.4	27.0	15.6	91.8	3	3
R609	5064.4	202.1	25.1	15.3	90.7	3	3
Z430	6144.2	215.4	28.5	16.3	90.4	3	3
6931	5286.0	198.7	26.6	15.4	89.6	3	2
R522	4110.3	201.2	20.4	15.3	90.5	3	3
R626	2708.1	206.6	13.1	15.2	91.9	3	3
6869	4777.2	195.6	24.4	15.0	90.2	2	3

Test 975BB: Comparison of selected varieties and releases.

<u>Variety</u>	<u>RWSA</u>	<u>RWST</u>	<u>T/A</u>	<u>Suc %</u>	<u>CJP %</u>	<u>Sprangle</u>	<u>Suture</u>
B5931	5537 A	236.1 BCD	23.4 A	17.0 B	92.37 ABCD	2.33 A	2.33 AB
ACH197	5479 A	245.4 AB	22.4 ABC	17.2 AB	93.57 A	1.67 AB	2.33 AB
ACH319	5182 AB	239.2 ABC	21.7 ABCD	17.3 AB	92.15 ABCD	1.33 AB	2.50 A
HME17	5181 AB	241.4 ABC	21.5 ABCD	17.1 B	93.01 ABC	1.33 AB	2.17 ABC
HME7	5062 ABC	223.2 DE	22.6 AB	16.3 C	91.84 BCD	1.33 AB	1.83 BCD
ACH185	5004 ABC	242.6 ABC	20.6 ABCD	17.4 AB	92.60 ABCD	1.33 AB	2.17 ABC
B5315	4745 BCD	252.4 A	18.8 BCD	17.7 A	93.36 AB	1.33 AB	2.33 AB
HME10	4475 CDE	241.2 ABC	18.5 BCD	17.0 B	93.33 AB	1.09 AB	2.21 ABC
ACH308	4460 CDE	244.5 ABC	18.3 CD	17.5 AB	92.61 ABCD	1.67 AB	2.17 ABC
SR94	4296 DEF	225.7 DE	19.1 BCD	16.2 C	92.53 ABCD	2.00 AB	1.67 CD
SR93	4167 DEF	204.5 F	20.4 ABCD	15.3 D	91.26 D	2.33 A	1.50 D
HME4	4125 DEF	230.4 CDE	17.9 D	16.4 C	92.89 ABCD	2.00 AB	2.50 A
USH20	3978 EFG	219.3 E	18.2 CD	16.0 C	92.09 ABCD	1.00 B	2.17 ABC
USH23	3949 EFG	218.5 E	18.1 CD	15.9 C	92.18 ABCD	2.00 AB	2.00 ABCD
96RR	3695 FG	203.6 F	18.2 CD	15.2 D	91.24 D	1.67 AB	2.00 ABCD
SR87	3438 G	196.6 F	17.5 D	14.6 E	91.52 CD	2.00 AB	1.50 D

Abbreviations: RWSA - recoverable white sugar per acre

RWST- recoverable white sugar per ton

T/A - tons per acre

%Suc - percent sucrose

%CJP - percent clear juice purity

Significantly different means at the 0.05 level are indicated by different letters (Duncan's Multiple Range)

1997 Stand: Visual rating of field establishment (high =no gaps, intermediate =one or more 3' gaps,

low = <10 plants per 30' row, none = no germination).

The assistance of the Michigan Sugar Co. sugar analysis laboratory is gratefully acknowledged.

# EVALUATION OF SMOOTH ROOT AND BREEDING LINES OF SUGARBEET - 1997

Joseph W. Saunders, J. Mitchell McGrath and Richard A. Kitchen

USDA-Agricultural Research Service

and Cooperative with Department of Crop and Soil Sciences

## **Cropping History and Background:**

The 1997 sugarbeet field trials at the Bean and Beet Research Farm near Saginaw were planted in Range 7, tiers 3 through 6. This land had been in soybeans in 1996. The soil was prepared by fall plowing, followed by frost tillage in the early spring. Beets were planted on April 25, 1997. Pre-emergence herbicide (3 qt. Pyramin and 2 qt. Nortron SC per acre) was banded onto the rows immediately following seeding. Seed germination was very good overall. The plots were thinned to 6-8" between plants within the row and weeded by the second week of July, resulting in good plant stands after thinning and weed control. Fertilizer at the standard recommended rate of 90 pounds available N per acre was applied to the soil on June 23, 1997 by side-dressing between rows. All experiments were machine harvested October 1-3, 1997. Sugar analysis was generously provided by the Michigan Sugar Co. sugar laboratory and their assistance is greatly appreciated.

A few new scores were added to the palette in 1997. In addition to the standardized smooth root scores (0-4 scale) developed previously, categories for the depth of suture, relative degree of sprangling and the preponderance of fibrous root hairs were included. All were scored on a scale of 1-3 with lower numbers being considered more desirable. Thus, the smoothest root would have a score of 0 on the early scale and be composed of scores of 1 for shallow suture, no sprangles and no fibrous roots. In practice, however, depth of suture is weighted most heavily in the early scoring system. Good agreement between the depth of the suture, but not sprangling, and previous year's smoothness scores was obtained. Canopy vigor was scored on a 1-3 scale, with the highest score considered the most luxuriant. Crown height was also scored on a 1-3 scale with the highest values protruding highest above the soil surface. All statistical analyses were performed with the aid of MSTAT and/or JMP. Differences between means were determined with Duncan's Multiple Range test, and judged significantly different by different letter suffixes following the means in the tables.

## **Results:**

Test 972BB was designed to evaluate performance for standard agronomic traits as well as conformation of the root and canopy, including an overall smooth root score. In addition to three commercial hybrid varieties (ACH185, B5931, HME17), two 1997 East Lansing ARS smooth root releases (SR93 and SR94), two older East Lansing ARS smoothroot releases (SR87 and SR80) from 1992 and 1990 respectively, and five prospective East Lansing ARS smoothroot releases (96HS3-01, 96HS12-01, WC960452, 96HS20-7, 97HS21-7). All prospective releases are derived from the East Lansing ARS breeding program of J. C. Theurer, now retired, that combined eastern US smoothroot sugarbeet germplasm with high sucrose percentage germplasm lacking in disease tolerance adaptation to the Great Lakes production area. This was a six replicate, four row test with only the middle two rows harvested.

The summary table for Experiment 972BB is ordered by Recoverable White Sugar per Acre (RWSA) performance. When sucrose percentages are examined, the twelve entries fall into four clusters of three seen by the first two digits of each sucrose percentage mean value. The three



commercial hybrids fall into the highest sucrose cluster; SR80, SR87 and SR93 fall into the lowest cluster. The high intermediate cluster is formed by SR94, 96HS3-01 and the low intermediate cluster is formed by 96HS12-01, 96HS20-7 and 96HS21-7. In general, the historical pattern of inverse relationship between sucrose percentage and root smoothness was seen in this test, although prospective releases 96HS20-7 and 97HS21-7 have root smoothness nearly as great as released germplasms SR87 and SR93. The least smooth of the prospective releases (96HS3-01 and WC960452) have a smoothness score of at least 2/3 of the distance from the roughest (i.e. the commercial varieties) to the smoothest. 96HS3-01 represents a productive line of breeding that combines moderate smoothness with moderately high sucrose percentage and acceptable root tonnage.

Test 972BB: evaluation of smooth root and breeding lines of sugarbeet - 1997

<u>Entry</u>	<u>RWSA</u>		<u>RWST</u>		<u>T/A</u>		<u>SUC %</u>		<u>CJP %</u>		<u>LS</u>	
B5931	<b>6084</b>	A	<b>242.4</b>	A	25.10	BC	17.31	A	92.65	AB	<b>3.25</b>	C
96HS3-01	6063	A	233.7	BC	25.95	BC	16.65	B	92.90	A	5.75	AB
96HS20-7	5859	AB	218.8	EF	26.80	AB	15.74	C	92.66	AB	5.00	ABC
ACH185	5778	AB	239.6	AB	24.12	C	<b>17.35</b>	A	92.04	ABCD	3.75	BC
96HS25	5753	AB	229.3	CD	25.09	BC	16.58	B	92.27	ABC	5.00	ABC
HME17	5747	AB	242.0	A	<b>23.75</b>	C	17.18	A	92.95	A	5.00	ABC
SR93	5705	AB	198.7	G	<b>28.69</b>	A	14.86	D	91.23	D	<b>6.25</b>	A
SR94	5687	AB	226.4	CDE	25.12	BC	16.34	B	92.39	AB	5.25	ABC
96HS12-01	5675	AB	221.3	DEF	25.64	BC	15.92	C	92.60	AB	4.75	ABC
97HS21-7	5557	AB	215.4	F	25.80	BC	15.80	C	91.85	BCD	5.25	ABC
SR87	5290	BC	<b>195.9</b>	G	27.02	AB	<b>14.61</b>	D	91.42	CD	5.00	ABC
SR80	<b>4846</b>	C	196.2	G	24.67	BC	14.69	D	91.22	D	3.50	C

	<u>SR</u>		<u>Suture</u>		<u>Sprangle</u>		<u>Canopy</u>		<u>Crown</u>		<u>Rhizoc.</u>	
B5931	<b>2.83</b>	A	<b>2.50</b>	A	<b>1.33</b>	B	<b>1.33</b>	C	1.67	AB	<b>3.9</b>	A
96HS3-01	1.92	BCD	1.92	CDE	1.67	AB	<b>2.50</b>	A	1.67	AB	3.4	A
96HS20-7	1.75	D	1.83	DEF	<b>2.33</b>	A	2.00	ABC	1.67	AB	3.6	A
ACH185	2.75	A	2.42	A	1.33	B	2.00	ABC	2.00	A	3.4	A
96HS25	1.92	BCD	2.00	CD	1.83	AB	1.67	ABC	1.67	AB	3.7	A
HME17	2.79	A	2.42	A	1.33	B	2.00	ABC	<b>2.00</b>	A	3.3	A
SR93	<b>1.63</b>	D	1.75	EF	2.33	A	2.17	ABC	<b>1.33</b>	B	3.5	A
SR94	2.21	B	2.08	BC	1.67	AB	2.17	ABC	1.50	AB	3.7	A
96HS12-01	1.88	CD	2.00	CD	1.83	AB	2.17	ABC	1.33	B	3.5	A
97HS21-7	1.75	D	1.83	DEF	2.00	AB	2.33	AB	1.33	B	3.6	A
SR87	1.67	D	<b>1.67</b>	F	2.00	AB	1.67	ABC	1.67	AB	<b>3.3</b>	A
SR80	2.17	BC	2.17	B	1.50	B	1.50	BC	1.33	B	3.5	A

(Bold indicates high and low range.)

## 1997 RHIZOCTONIA CROWN AND ROOT ROT NURSERY — BREEDING LINES AND ARS RELEASES (TEST 977R2).

Joseph W. Saunders, John M. Halloin, and J. Mitchell McGrath, USDA, Agricultural Research Service, Sugarbeet and Bean Research Unit, Department of Crop and Soil Sciences (JWS, JMM) and Department of Botany and Plant Pathology (JMH), Michigan State University, East Lansing MI 48824.

The 1997 *Rhizoctonia* disease nursery included the four replication test 977R2 which encompassed a range of germplasm. Plants were scored on a scale of 0-4, with 0 = no lesions found, 1 = up to 25% of the root covered with lesions, and 4 = 76-100% of the root covered with lesions. Dead or missing plants were scored as a 4. The susceptible checks were USH20 and USH23, and the resistant check was 96RR, scheduled for release in 1998 as EL51. FC701/5 was included as a resistant check but very poor stand resulted, apparently accounting for the relatively high score. This test was conducted on ground that had not been inoculated with *Rhizoctonia* before, and the intensity of the disease was fairly high, at least as measured by the ratings for 96RR in this test compared with the commercial variety test, for example.

Two groups of monogerm half-sib families (97J21, 97J26), each tracing back to different grandmother clones but a common paternity population in the 85B1 crossing block, represent prospective release material after more cycles of selection and intercrossing. The background is traditional East Lansing germplasm with excellent tolerance to *Aphanomyces* and *Cercospora* and with enhanced frequency of the *x* and *z* cms maintainer alleles.

EL48 is a near-O type monogerm line from the traditional East Lansing germplasm pool, released in 1984. It has no crown rot tolerance. Five Fargo storage rot tolerant lines were tested, with F1002 rating highest but not significantly better than any other of the five. The absolute worst score was taken for C51, a recent ARS-Salinas release for hot temperature root rot tolerance. It did not demonstrate any cross-tolerance to *Rhizoctonia* at East Lansing (nor to *Aphanomyces* in the Betaseed root rot test at Shakopee MN).

### 1997 RHIZOCTONIA NURSERY TEST 977R2

GERMPLASM	RHIZOCTONIA SCORE MEAN, LSD (0.05)=0.55
96RR (EL51)	2.92
97J26 (18 LINES)	3.14 (RANGE 2.71 - 3.60)
97J21 (3 LINES)	3.39 (RANGE 3.07 - 3.68)
USH20	3.46
USH23	3.32
FC701/5	3.59 (POOR STAND)
EL48	3.70
F1002	3.32
F1006	3.54
F1001	3.78
F1005	3.80
F1004	3.81
C51 (SAL)	3.91

## DEVELOPMENT OF SUGARBEET IN VITRO SYSTEMS FOR EVALUATION OF HOST PATHOGEN INTERACTION

Joseph W. Saunders and Peter S. Hudy

In vitro systems have a number of advantages for characterizing plant defense responses, primarily experimental control of the physical and chemical environment. Tissue culture systems, a subset of in vitro systems, are by definition axenic (defined presence of only one, or more, species or subspecific entities) and have reductionist advantages because both the integrity of the whole plant is usually sacrificed to permit work with isolated organs or dividing cells, and because the interactions between species of the phyllar or soil microfloral community or with inconstant environment are eliminated. Nonsterile pieces of plant tissue (eg, leaves, or root cylinders) are used in another subset of in vitro systems. Control of the composition of the microflora in the system is compromised in exchange for greater availability of plant material, at lower cost.

There has been little research in plants dealing with co-culture of host and pathogen. The reason for this was evident when we inoculated standard Murashige-Skoog (MS) medium, used for sugarbeet tissue culture, with myceliar agar plugs (either from water agar or potato dextrose agar) of *Rhizoctonia solani* (RZT), either with or without an accompanying piece of sugarbeet root culture or leaf disc: RZT mycelium quickly swarmed over the plate, behaving saprophytically as it fed on the sucrose provided at 3% as the routine plant tissue culture carbon source. Whatever RZT did with the beet tissue it overran was a very minor part of the action going on in the plate. Even challenging RZT with the individual components of the nitrogen complement in MS medium, nitrate and ammonium, instead of the usual 40:20=60 mM mix of the two, didn't affect the ability of the RZT mycelium to grow well: it used either one fairly well.

As an alternative system to characterize the interaction of sugarbeet tissue with RZT, and to explore the prospects of obtaining single gene RZT tolerant mutants, we have grown RZT in MS medium with sugarbeet cell walls as the sole carbon source. Partially spent culture medium containing the secreted pectin lyase (PNL) enzyme activity was physically cleaned through a series of filters of decreasing pore size to yield a sterile culture filtrate (CF). This fungal product when incorporated into the standard suspension plate-out MS medium partially inhibited the growth of REL-1 cell clusters when it (ie, CF) constituted only 5% of the medium volume, and totally killed the cells when CF constituted 50% of the medium volume. Cause of death is assumed to be loss of cell wall integrity, but the presence of other toxins has not been ruled out at this time. Selection of resistant cells should be feasible in this system, although more precise understanding of the nature of the beet cell demise is desirable.

Interestingly, mycelium of *Aphanomyces cochlioides* (APH) displays rather different response behavior when inoculated onto MS medium. The mycelium grows at approximately the same lateral rate whether on potato dextrose agar (PDA), water agar, or standard MS medium. However, APH mycelium only grows thinly on water agar or MS medium, and does not sustain growth, presumably only growing as much as is permitted by the nitrogen it carried along internally or in the inoculum plug. APH grows well with yeast extract or glutamine as the sole nitrogen source in MS medium, but not sustainably with nitrate or ammonium alone (or of course the 40:20=60 mM combination in standard MS medium).

When APH inoculum plugs are prepared from water agar [cultures] (that is, starvation cultures where the APH derives nitrogen sustenance from what comes in the inoculum plug), and are used to inoculate remotely positioned cultured growing root masses of sugarbeet, APH mycelium grows thinly through the agar, then explodes in growth when it reaches the beet tissue. Plated out suspension cultures as well as leaf discs are also killed by their interaction with APH in this system. We are still looking for ways to further disadvantage APH in this interaction and create a level playing field.

These sugarbeet tissue culture systems are in their early developmental stages. Prospects are good for their benefit in evaluating germplasm, selection of resistant variants, characterizing host defense mechanisms, and teasing apart various aspects of pathogen attack.

## NOTICE OF RELEASE OF SR94 SMOOTH ROOT SUGARBEET GERMPLASM

The Agricultural Research Service of the U. S. Department of Agriculture, the Michigan Agricultural Experiment Station, and the Beet Sugar Development Foundation announce the joint release of SR94, a smooth root sugarbeet germplasm selected for soil-free harvest. SR94 was developed at the Sugarbeet and Bean Research Unit, East Lansing, Michigan by the sugarbeet breeding team of Drs. J. C. Theurer (now retired), J.W. Saunders, J. M. McGrath, and J.M. Halloin.

SR94 has moderate root smoothness and sucrose percentage that are equivalent to that of SR80 released in 1992. SR94 has a higher sucrose percentage than SR87 and SR93 and has broader genetic diversity than SR87 or SR80. SR94 is an open-pollination increase of synthetic seed produced from three cycles of mass selection for smooth root and high sucrose percentage, following three individual plant pair crosses of beets with high sucrose percentage and smoothroot beets selected from smoothroot line SP85700. One high sucrose percentage root each came from F<sub>1</sub> hybrids C40 x L19, C51 x L19, and C51 x 46I1. C40 (8400040) and C51 (8400051) are high sucrose percentage lines kindly provided by Crystal-Maribo Seeds. L19 is a high sucrose percentage line from the former USDA-ARS sugarbeet breeding program at Logan UT, selected from progeny of a collection of miscellaneous high-sugar lines crossed with the Polish variety Udyca. 46I1 is a high sucrose percentage curly top resistant line also developed in the ARS Logan program. The germplasm base of SR94 is approximately 50 percent SP85700, 18 percent L19, 18 percent C51, 7 percent C40 and 7 percent 46I1.

SR94 is diploid multigerm and segregates for red and green hypocotyl. SR94 is relatively easy bolting, and male fertile plants are largely self-sterile with a significant degree of pseudo-self-fertility under individual plant isolation. Male sterility exceeds twenty percent, and its source in the pedigree is unknown. SR94 has been tested under the identification 94HS21 where it has yielded sucrose concentrations 95 percent of that of commercial cultivar ACH185. *Cercospora* leaf spot rating for SR94 was 65 percent less tolerant than that of commercial cultivar ACH185.

SR94 is being released as a germplasm source for breeders to use in developing smooth root breeding lines or cultivars. Seed will be maintained by USDA-ARS and is available for use by writing to Dr. J. Mitchell McGrath, USDA-ARS, Crop and Soil Science Department, Michigan State University, East Lansing, MI 48824-1325. Genetic material of this release will be deposited in the National Plant Germplasm System where it will be available for research purposes, including development and commercialization of new cultivars. It is requested that appropriate recognition be made if this germplasm contributes to the development of a new breeding line or cultivar.

**SUGARBEET RESEARCH**

**1997 REPORT**

**Section F**

**Texas Agricultural Experiment Station  
Bushland, Texas**

**Dr. C. M. Rush, Professor**

**Cooperation:**

**Holly Sugar Corporation – Sugar Land, Texas  
Western Sugar Company – Denver, Colorado**

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**PICCINNI, G., C.M. Rush, M.L. Fahnert, L.L. New. 1997. Control of soilborne pathogens by managing irrigation of sugar beet. *Phytopathology*, 87:S77**

Two experiments were conducted to evaluate the effect of several irrigation regimes on disease development in sugar beet. The first experiment included four irrigation regimes (every two, three, four and five weeks) and four inoculation treatments (BNYVV, BSBMV, BNYVV+BSBMV and non-inoculated control). The treatment irrigated every four weeks showed the lowest disease incidence and a yield that was not significantly different from the treatment irrigated every two weeks. Also, sucrose content was significantly higher in the four-week irrigation treatment than in treatments irrigated every two and three weeks. Plots inoculated with BNYVV had a significantly higher disease incidence than BSBMV and BNYVV+BSBMV treatments. Yields were also significantly affected by the inoculation treatments. Beets in the BNYVV+BSBMV treatment had a significantly higher yield than beets in the BNYVV treatment. The second experiment included three frequencies, three amounts and two methods of irrigation under a center pivot system. Sugar beets irrigated every other time the grower applied irrigation had the highest yield and the lowest disease incidence.

**PICCINNI, G., C.M. RUSH, and M.L. FAHNERT. 1997. Control of soilborne pathogens by managing irrigation of sugar beet. *In: ASSBT Proceedings of 29<sup>th</sup> Bi-Annual Meeting*, pg. 194.**

Two soilborne sugar beet viruses known to occur in the Texas Panhandle, beet necrotic yellow vein virus (BNYVV) and beet soilborne mosaic virus (BSBMV), are transmitted by the fungus *Polymyxa betae*. The incidence and severity of diseases caused by soilborne viruses and fungi can be higher when a precise irrigation schedule is not followed. Fields are often irrigated excessively, based on the assumption that increasing the amount of water applied to the crop increases tonnage. However, this assumption is incorrect when field soils are infested with soilborne pathogens. The goal of this research is to identify the economic threshold of yield reduction due to soilborne pathogens in order to provide growers with useful information to maximize net return by saving water and energy and reducing chemical applications. An experiment was conducted in Bushland, Texas, in order to quantify the effects of different irrigation frequencies on sugar beet yield under disease pressure. Four irrigation regimes (every two, three, four and five weeks) and four inoculation treatments (BNYVV, BSBMV, BNYVV+BSBMV and non-inoculated control) were arranged in a split-plot design replicated four times. Crop growth, soil moisture, disease incidence, yield and sucrose content were evaluated. The treatment irrigated every four weeks showed the lowest disease incidence and a yield that was not significantly different from the treatment irrigated every two weeks. Also, sucrose content was significantly higher in the four-week irrigation treatment than in treatments irrigated every two and three weeks. Plots inoculated with BNYVV had a significantly higher disease incidence than BSBMV and BNYVV+BSBMV treatments. Yields were also significantly affected by the inoculation treatments. Beets in the BNYVV+BSBMV treatment had a significantly higher yield than beets in the BNYVV treatment.

**FAHNERT, M.L., G. PICCINNI, C.M. RUSH, and L.L. NEW. 1997. Effect of different irrigation regimes on sugar beet growth in a disease stressed field. In: ASSBT Proceedings of 29<sup>th</sup> Bi-Annual Meeting, pg. 195.**

A study was conducted to evaluate the effect of frequency and amount of irrigation on disease development in sugar beets. The objective of the study was to determine the optimum irrigation regimes for the highest yield and percent sucrose in a soilborne pathogen infested field. There were three main irrigation treatments: a Low Energy Precision Application (LEPA) system where 100%, 75% and 50% of the full rate of the pivot system (800 gpm) was applied, a LEPA system with on/off valves in which the plots were irrigated at different frequencies, including every time, every other time, and every third time the grower irrigated, and a system in which the canopy was irrigated from above with 100%, 75%, and 50% the full rate of the sprinkler system. During the season, the following measurements were taken: top fresh weight, top dry weight, root fresh weight and number of beets per meter. Soil moisture was measured every foot, to a depth of six feet using a hydroprobe moisture gauge. At harvest, root yield, number of beets per meter, disease index, percent sucrose, and stand counts were determined. The highest percent sucrose (13.5) and lowest disease indices were in plots irrigated at different frequencies. Based on three 25 ft. subplots replicated four times, sugar beets irrigated every other time had the highest yields, while sugar beets that were irrigated every third time had the lowest yield. The highest disease index and lowest percent sucrose occurred in plots irrigated at the full rate. There were no significant differences in sugar beet net weight or disease index among the treatments where different amounts of water were applied. However, in the treatments irrigated the least there was a significantly higher percent sucrose than in those irrigated at the full rate. These results are from the first year of a multiple-year study. They indicate that disease losses can be reduced and yields increased with improved irrigation management.

**RUSH, C.M., K-B.G. SCHOLTHOF, E.B. TELFORD. 1997. Nucleotide Sequence and Genomic Organization of Beet Soilborne Mosaic Virus RNA 2. Phytopathology 87:S83**

Studies were conducted to further define the taxonomic relationship between beet soilborne mosaic virus (BSBMV) and beet necrotic yellow vein virus (BNYVV). RT-PCR products comprising 4,546 bases from BSBMV RNA2 were cloned and sequenced and data were compared with sequence from several closely related viruses. Six putative open reading frames (ORFs) were identified on BSBMV, which were nearly identical in size and position to those of BNYVV RNA2. Best fit comparisons of amino acid sequence homology from each individual ORF of BSBMV and BNYVV revealed a low of 40% identity and 62% similarity in ORF 6 and a high of 81% identity and 90% similarity in ORF 4. Sequence homology of BSBMV with other furoviruses possessing triple gene block sequences rarely exceeded 30% identity. Similarities between BSBMV and BNYVV suggest they represent a sub-group within the furoviruses. Analysis of BSBMV RNA3 will be required to determine BSBMV's potential for virulence.

**RUSH, C.M.<sup>1</sup>, K-B.G. SCHOLTHOF, and E.B. TELFORD. 1997. Analysis of beet soilborne mosaic virus RNA 2 nucleotide sequence. In: ASSBT Proceedings of 29<sup>th</sup> Bi-Annual Meeting, pg. 211.**

Beet soil borne mosaic virus (BSBMV), vectored by *Polymyxa betae*, is widespread throughout many of the major sugar beet production areas of the United States but has not been identified outside the USA. Over the last two years, sugar beets exhibiting typical symptoms of rhizomania but testing negative for beet necrotic yellow vein virus (BNYVV) and positive for BSBMV have been recovered from Texas, Colorado, Nebraska, and Minnesota. It is unknown whether the isolates of BSBMV associated with rhizomania-like symptoms cause these symptoms or whether the symptoms are due to environmental conditions or some other unidentified factor. In addition to possible similarities in symptom expression, there have also been reports of serological similarities. In an attempt to better understand the relationship between BSBMV and BNYVV, RNA 2 of BSBMV was cloned and sequenced and the sequence and genomic organization was compared to that of BNYVV. Six putative open reading frames (ORFs) were identified on BSBMV, which were nearly identical in size and position to those of BNYVV RNA 2. Comparisons of amino acids encoded by each ORF from BSBMV and BNYVV indicated that the lowest match was 62% in ORF 6, and the highest was 90% in ORF 4. Sequence homology of BSBMV with other furoviruses rarely exceeded 30% similarity. These results indicate that BSBMV and BNYVV are more closely related to each other than to other furoviruses. Because of the genomic similarity between BSBMV and BNYVV, it would not be surprising if some isolates of BSBMV may be able to cause severe disease similar to rhizomania in sugar beets.

**HAVESON, R.M., C.M. RUSH, AND H.C. KISTLER. Biological Characterization of *Fusarium Oxysporum* Isolates Pathogenic to Sugar Beets. Phytopathology 87:S40**

*Fusarium* root rot, caused by *Fusarium oxysporum* f.sp. *betae*, is one of several fungal root diseases of sugar beets causing significant yield losses to Texas producers. It is distinct from *Fusarium* yellows by inducing a severe rot at the distal end of the taproot rather than wilting and yellowing of foliage. Vegetative compatibility testing has indicated that Texas isolates differ genetically both among themselves and with those from other sugar beet growing areas of the U.S. This study was begun to further characterize a selection of 5 Texas isolates representing different vegetative compatibility groups, symptom types, and hosts. Radial growth at 6 temperatures - 10,15,20,25,30, & 35°C was measured for each isolate begun from a single spore. Six to eight week old plants were dip inoculated with a microspore suspension and transplanted in field soil in PVC tubes held at 20" and 30"C in controlled temperature boxes in the greenhouse. Two different irrigation regimes were also evaluated. Data collected after 8 weeks included a root disease index, root dry weight, and foliar dry weight. Disease indices at 30"C showed that three isolates were severe, one was mild, and one was intermediate. At 20"C only one isolate caused any appreciable root rot. Irrigation frequency had no effect upon pathogenicity. Results indicate that isolates differ significantly in the ability to grow and cause disease at different temperatures, further suggesting substantial variation among Texas populations.

**WINTER, S.R., C.SCHLABS, AND C.M. RUSH. 1997. A Grower's Perspective on Soil-borne Disease Management. . In: ASSBT Proceedings of 29<sup>th</sup> Bi-Annual Meeting, pg. 191.**

Soil-borne diseases have taken a huge toll on the Texas sugarbeet industry. At Schlabs farm, yields averaged 29, 27, 23, and 17 tons/acre for first through fourth beet crops on a 4-year rotation. A comprehensive disease management program has brought yields back to 25.5 tons/acre when using Telone II and 22.1 tons/acre without Telone. The primary elements of this program are: an 8-year rotation, plant after summer fallow to minimize prior crop residues (primarily for *Rhizoctonia* control), thick stands in narrow rows planted early (double row 40-inch, 90,000 seed/acre, without thinning), one irrigation for emergence, never replant late, chisel Telone 14 inches deep under each row 2 wks. before planting at 8 gal/acre, delay first seasonal irrigation until July 1, irrigate no closer than a 3-wk interval during July and August, and plant a disease resistant cultivar. Telone has returned a little less than two dollars for each dollar invested. The best cultivars appear to be *Fusarium* tolerant and seem to have a generalized tolerance to our soil-borne disease complex. Choosing the proper cultivar and avoiding over-irrigation are the primary components of profitable disease management.

**HEIDEL, G. B., C. M. RUSH, T. L. KENDALL, S. A. LOMMEL, AND R. C. FRENCH, 1997. Characteristics of Beet Soilborne Mosaic Virus, a Furo-like Virus Infecting Sugar Beet. Plant Dis. 81:1070.**

Beet soilborne mosaic virus (BSBMV) is a rigid rod-shaped virus transmitted by *Polymyxa betae*. Particles were 19 nm wide and ranged from 50 to over 400 nm, but no consistent modal lengths could be determined. Nucleic acids extracted from virions were polyadenylated and typically separated into three or four discrete bands of variable size by agarose-formaldehyde gel electrophoresis. RNA 1 and 2, the largest of the RNAs, consistently averaged 6.7 kb and 4.6 kb, respectively. The sizes and number of smaller RNA species were variable. The molecular mass of the capsid protein of BSBMV was estimated to be 22.5 kDa. In Northern blots, probes specific to the 3' end of individual beet necrotic yellow vein virus (BNYVV) RNAs 1-4 hybridized strongly with the corresponding BNYVV RNA species and weakly with BSBMV RNAs 1, 2, and 4. Probes specific to the 5' end of BNYVV RNAs 1-4 hybridized with BNYVV but not with BSBMV. No cross-reaction between BNYVV and BSBMV was detected in Western blots. In greenhouse studies, root weights of BSBMV-infected plants were significantly lower than mock-inoculated controls but greater than root weights from plants infected with BNYVV. Results of serological, hybridization, and virulence experiments indicate that BSBMV is distinct from BNYVV. However, host range, capsid size, and the number, size and polyadenylation of its RNAs indicate that BSBMV more closely resembles BNYVV than other members of the genus *Furovirus*.

# ETIOLOGY AND EPIDEMIOLOGY OF RHIZOMANIA DISEASE COMPLEX

(BSDF Project 503)

## MOLECULAR STUDIES OF BSBMV

Beet soil borne mosaic virus (BSBMV – previously Tx7) is a pathogen of sugar beets that is wide spread throughout most of the sugar beet growing regions of the United States. It has numerous similarities with beet necrotic yellow vein virus (BNYVV) including host range, fungal vector, particle shape and size, number of RNAs, and weight of its coat protein. BSBMV can confer cross protection against BNYVV (see results of cross protection studies in this report) and before molecular methodologies became widely available, this and the other similarities between BNYVV and BSBMV would have been adequate to designate BSBMV a strain of BNYVV. One major difference between BNYVV and BSBMV is that BSBMV typically doesn't cause severe disease. However, over the last few years, beets exhibiting typical symptoms of rhizomania tested positive for BSBMV in ELISA tests but negative for BNYVV. We are uncertain whether some isolates of BSBMV are capable of causing rhizomania – like symptoms or whether these beets were infected by BNYVV initially and then BSBMV took over. Another complicating occurrence is that some isolates of BSBMV react with BNYVV antiserum resulting in false positives in the ELISA test. Because of the similarities between BNYVV and BSBMV, and the potential for BSBMV to cause confusion in diagnostic tests and possibly even cause disease symptoms similar to rhizomania, it is important to determine the true relationship between BNYVV and BSBMV. Therefore, we initiated studies to determine the genetic makeup of BSBMV and compare it with BNYVV. With these studies we hope to be able to determine whether BSBMV has the potential to cause disease symptoms similar to rhizomania.

## MATERIALS AND METHODS

Isolates of BSBMV have been collected from several of the major sugar beet growing regions around the country. In this study, three isolates were used: BSBMV-EA, BSBMV-RC, and BSBMV-PL. The EA and RC isolates came from Colorado and the PL isolate from Texas. The EA isolate is the typical BSBMV type and has been used in all sequencing work and most field and greenhouse studies. BSBMV-RC causes typical BSBMV type symptoms on beets but has an abnormal serological reaction, i.e. it fails to react with BSBMV antiserum and can have a partial reaction with BNYVV antiserum. BSBMV-PL has typical serological reactions but is one of the isolates associated with rhizomania symptoms. All isolates are maintained in the greenhouse on infected sugar beet plants to reduce the likelihood of mutations developing, a natural occurrence when these viruses are repeatedly mechanically inoculated to a host.

For molecular evaluations of these isolates, symptomatic leaf tissue from infected sugar beets is collected and processed in the laboratory. The virus is purified from the leaves and then cloned using standard molecular techniques. Clones of each virus are sent to the gene technology laboratory in College Station for sequencing i.e. determination of the nucleotide sequence of the virus. Once the nucleotide sequence is determined, the virus' genomic organization can be compared with that of BNYVV by computed analysis.

Figure 1. BSBMV RNA 2 Sequence

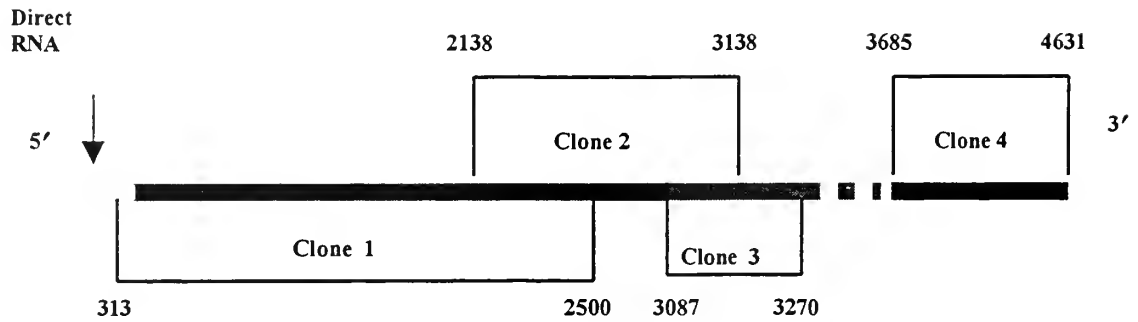


Figure 2. Sequence Homology Between Terminal Regions of BNYVV and BSBMV RNA 2

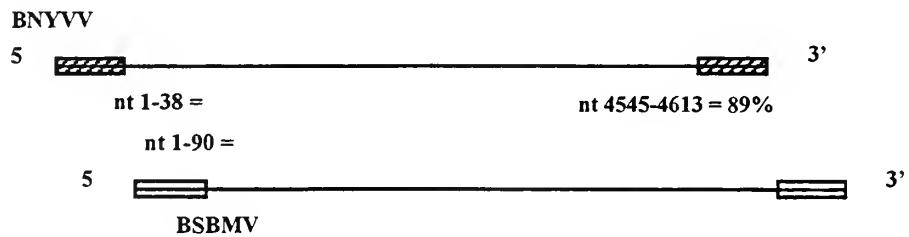
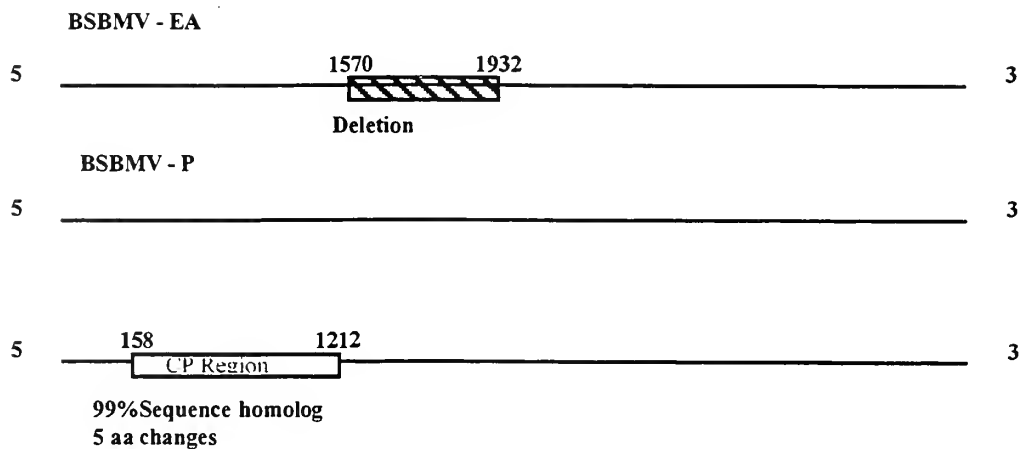


Figure 3. Variation in RNA 2 Among BSBMV Isolates





## RESULTS AND CONCLUSIONS

Four clones of BSBMV-EA were obtained that comprise approximately 95% of BSBMV RNA2 (Fig.1). A small region between clone 3 and 4 has proved to be recalcitrant to cloning but the region was sequenced directly using PCR techniques. The initial 200 bases near the 5' end of RNA2 were also not cloned but sequenced directly. All together the total number of nucleotides (nt) in BSBMV-EA RNA2 was 4,616 compared to 4,612 with BNYVV. In addition to the number of nucleotides being similar, the identity of nucleotides was also similar between BSBMV and BNYVV (Fig.2). Approximately 100 nt on both the 5' and 3' ends of BSBMV equaled or exceeded 85% homology with the same region of BNYVV. BNYVV has six gene coding regions on RNA2 including genes for the coat protein and genes that are involved in cell to cell movement. When the sequence of BSBMV was analyzed, it was determined that BSBMV also has six gene coding regions and they were in the same size and in the same location as those on BNYVV. Regions of nt homology exceeding 90% were not uncommon between BNYVV and BSBMV, although there were regions that exhibit less than 65% homology. The same level of sequence homology was observed on BSBMV RNAs 1,3, and 4. The high degree of similarity between these two viruses indicates that they are extremely closely related, more so than any other of the furoviruses group.

When nucleotide sequence among the three isolates of BSBMV was compared, we found an extremely high degree of sequence homology, typically exceeding 95%. However, there were differences (Fig.3). BSBMV-EA has a region of approximately 400nt that drops out after repeated mechanical passage to alternate hosts. The impact of this mutation is unknown, but it doesn't seem to occur in the other two isolates. BSBMV-RC which is known to have an atypical serological reaction to BSBMV antiserum and cross react with BNYVV antiserum was found to differ from BSBMV-EA by only 8nt which translated to only 5 amino acid changes. It was surprising that such a small variation in nucleotide sequence could result in such a significant and important change in the serological reaction. The variation that might be observed with BSBMV-PL in relation to its rhizomania-like symptoms has not yet been determined. Symptom expression with BNYVV is coded by genes on RNA 3 and we will likely find the same thing with BSBMV. If BSBMV-PL is truly capable of causing rhizomania-like symptoms, we will likely find the genetic reason on RNA3. At present we have sequenced approximately 75% of RNA3 and will continue this project. Once we obtain the entire sequence we will compare the sequence with BNYVV and also look at the amount of variation that exists among isolates of BSBMV from different geographical regions across the United States.

## COMPARISON OF SEROLOGICAL TESTS FOR THE DETECTION OF BNYVV AND BSBMV

Beet necrotic yellow vein virus (BNYVV) and beet soilborne mosaic virus (BSBMV) are soilborne viruses transmitted by *Polymyxa betae*. They are similar in terms of particle number and morphology and in the number, size, and polyadenylation of viral RNA species. However, BNYVV is the cause of rhizomania, a disease characterized by root stunting and hairiness that leads to losses in both tonnage and sugar content, while of the isolates studied, BSBMV causes some damage to sugar beets, but not as much as BNYVV.

**Table 1.** Samples collected from a sugar beet field in Minnesota and tested by DAS or indirect F(ab')<sub>2</sub> ELISA for BNYVV and BSBMV

Test	DAS	DAS	Commercial <sup>1)</sup>	Western blot		DAS	DAS	F(ab') <sub>2</sub>	F(ab') <sub>2</sub>	F(ab') <sub>2</sub>	F(ab') <sub>2</sub>
Antiserum	BSBMV-den <sup>x</sup>	BNYVV-den <sup>x</sup>	BNYVV	BSBMV-den	BNYVV-den	BSBMV-whl <sup>z</sup>	BNYVV-whl <sup>z</sup>	BSBMV-whl	BNYVV-den	BSBMV-whl	BSBMV-den
Sample No.											
1	+	+	+	+	+	+	+	+	-	+	-
2	-	+	+	-	+	-	+	+	-	-	-
3	-	+	+	-	+	-	+	+	+	-	-
4	+	+	+	+	+	+	+	+	-	+	-
5	-	+	+	-	+	-	+	+	Weak Positive	-	-
6	-	+	+	-	+	-	+	+	Weak Positive	-	+
7	-	+	+	-	+	-	+	+	Weak Positive	-	-
8	-	+	+	-	+	-	+	+	+	-	-
9	-	+	+	-	+	-	+	+	-	-	-
10	+	+	+	+	+	+	+	+	-	+	-
11	-	+	+	-	+	-	+	+	-	-	-
12	-	+	+	+	+	+	+	+	Weak Positive	+	-
13	-	+	+	-	+	-	+	+	-	-	-
14	-	+	+	-	+	-	+	+	+	-	-
15	-	+	+	+	+	+	+	+	+	+	-
16	-	+	+	-	+	-	+	+	+	-	-
17	-	+	+	-	+	-	+	+	-	-	-
18	+	+	+	-	+	-	+	+	-	-	-
19	-	+	+	-	+	-	+	+	-	-	-
20	-	+	+	+	+	-	-	+	-	+	-
21	-	+	+	-	+	-	+	+	-	-	-
22	-	+	+	-	+	-	+	+	-	-	-
23	-	+	+	-	+	-	+	+	+	-	-
24	-	+	+	-	+	-	+	+	-	-	-
25	-	+	+	-	+	-	+	Weak Positive	-	-	-
26	Weak Positive	+	+	+	+	+	-	+	-	+	-
27	-	-	+	+	+	-	+	+	-	-	-
28	+	+	+	+	+	+	-	+	-	+	+
29	-	+	+	-	+	-	+	+	-	-	-
30	+	+	+	+	+	+	+	+	+	-	-
No. (+)	7	29	30	10	25	27	8	29	11	8	2
% (+)	23	97	100	33	83	90	27	97	37	27	7
% (+) relative to western	70	116	120	.	.	108	80	116	44	80	20

<sup>x</sup> IgG was purified from antiserum developed to BSBMV or BNYVV denatured capsid.

<sup>y</sup> IgG and IgG-alkaline phosphatase conjugate were obtained from American Plant Diagnostics.

<sup>z</sup> IgG was purified from antiserum developed to BSBMV or BNYVV whole virus particles.

**Table 2.** Samples collected from a sugar beet field in Texas and tested by DAS or indirect F(ab')<sub>2</sub> ELISA for BNYVV and BSBMV

Test	DAS		Commercial <sup>y</sup>	Western blot		DAS		F(ab') <sub>2</sub>		F(ab') <sub>2</sub>		F(ab') <sub>2</sub>
	BSBMV-den <sup>s</sup>	BNYVV-den <sup>s</sup>		BSBMV-den	BNYVV-den	BNYVV-whl <sup>z</sup>	BSBMV-whl <sup>z</sup>	BNYVV-whl	BNYVV-den	BSBMV-whl	BSBMV-den	
Sample No.												
1	-	-	+	-	+	+	-	+	+	-	+	+
2	-	+	+	-	+	+	-	+	+	-	-	-
3	+	+	+	Weak Positive	+	+	+	+	-	-	+	+
4	-	+	+	-	+	+	-	+	+	-	-	-
5	-	-	+	-	+	+	-	+	+	+	+	+
6	-	-	+	-	+	+	-	+	+	+	+	+
7	-	+	+	-	+	+	-	+	+	-	+	+
8	-	-	+	-	+	+	-	+	+	+	+	+
9	-	+	+	Weak Positive	+	+	-	+	+	-	-	-
10	-	+	+	-	+	+	-	+	+	-	+	+
11	+	-	+	+	-	+	+	+	+	-	+	+
12	-	-	+	-	Weak Positive	+	-	+	+	-	+	+
13	-	+	+	-	+	+	-	+	+	-	+	+
14	-	-	+	-	Weak Positive	+	-	+	+	-	+	+
15	-	-	+	-	-	+	-	+	+	-	+	+
16	-	-	-	-	+	+	-	-	-	-	-	-
17	+	+	+	Weak Positive	+	+	-	+	+	-	+	+
18	-	-	+	-	+	+	-	+	+	-	-	-
19	+	+	+	+	-	+	+	+	+	+	+	+
20	-	-	+	-	+	+	-	+	+	+	+	+
21	-	-	+	-	+	+	-	+	+	+	+	+
22	-	-	+	-	+	+	-	+	+	-	-	-
23	-	-	+	-	Weak Positive	+	-	+	+	-	+	+
24	-	-	+	Weak Positive	+	+	-	+	+	-	-	-
25	-	+	+	-	-	+	-	-	-	-	-	-
26	-	+	+	-	+	+	-	+	+	-	-	-
27	+	+	+	+	+	+	+	+	+	+	+	+
28	-	-	+	-	+	+	-	+	+	-	+	+
29	-	-	+	-	-	+	-	-	+	-	+	+
No. (+)	5	12	28	7	24	29	4	26	25	6	19	19
% (+)	17	41	97	24	83	100	14	90	86	21	66	66
% (+) relative to western	71	50	117	.	.	121	57	108	104	86	271	271

<sup>s</sup> IgG was purified from antiserum developed to BSBMV or BNYVV denatured capsid.  
<sup>y</sup> IgG and IgG-alkaline phosphatase conjugate were obtained from American Plant Diagnostics.  
<sup>z</sup> IgG was purified from antiserum developed to BSBMV or BNYVV whole virus particles.

Routine detection of these viruses is often accomplished by serological testing, usually by western blot or by ELISA. Western blots are sensitive and reliable but are also time-consuming and, because of the nature of the test, not suitable for testing large numbers of samples. For this,

ELISAs are more practical. Depending on the conditions of the test and the antiserum used, cross-reaction has been reported between BSBMV and BNYVV in both western blot and ELISA tests. Correct diagnosis is important. For this reason, a study was conducted, to gain a better understanding of the variation that might occur when using different antisera developed to BNYVV and BSBMV in different types of ELISA tests.

## **MATERIALS AND METHODS**

Antisera were developed in rabbits to BNYVV and BSBMV whole virus (whl) and denatured capsid (den). IgG was fractionated from each of the four sera (BNYVV-whl, BNYVV-den, BSBMV-whl, and BSBMV-den). Two types of ELISA were used. In DAS ELISAs, plates were coated with IgG, samples were added and then probed with a secondary biotin-labeled IgG. The secondary IgG was then detected with avidin-conjugated alkaline phosphatase. In the second type of ELISA, F(ab')<sub>2</sub> indirect ELISA, plates were coated with F(ab')<sub>2</sub> fragments generated from the four antisera, and samples were probed with the corresponding unfractionated antiserum. Protein-A conjugated alkaline phosphatase was used to detect the antiserum probe. For control tests, samples were analyzed by western blot using BNYVV-den and BSBMV-den antisera and by DAS ELISA using BNYVV IgG and alkaline phosphatase-conjugated BNYVV IgG obtained from a commercial source (American Plant Diagnostics, Inc., South Bend, IN). Buffers used in all ELISAs were the same, and plates were incubated under the same conditions. Root samples were ground in sample buffer at a ratio of 1:10 (w:v).

Sugar beets exhibiting root and/or foliar symptoms indicative of potential BNYVV or BSBMV infection were selected for testing. Samples were collected from one field in Minnesota and eight fields in Texas in September and October 1997. Approximately 250 samples were analyzed. About 120 samples were also collected from a field study conducted on experiment station land in Bushland, Texas. These samples were collected from plots infested with BNYVV and two BSBMV isolates. Tests are still in progress; preliminary results from two fields will be presented here.

## **RESULTS AND DISCUSSION**

Results of ELISAs and western blots are summarized in Tables 1 and 2. BSBMV results are in the shaded columns. Test results are shown for individual beets, and the percentage of beets positive in a particular test is indicated. Western blot results were chosen as a standard for comparison, and the percentage of beets positive in a test relative to the respective number of beets positive as determined by western blot are indicated.

Thirty samples were collected from the sugar beet field located in Minnesota (Table 1). Results varied among the tests. Relative to western blot results, the percentage of positive beets detected ranged from 20% for the F(ab')<sub>2</sub> test using BSBMV-den antiserum to 120% for the test using BNYVV IgG from a commercial source. Results from six out of nine tests (including the

commercial BNYVV test) fell within plus or minus 20 percentage points of western results. Most of the F(ab')<sub>2</sub> tests detected fewer positive samples than did western blot analyses.

Conversely, more positive samples were detected from the field sampled in Texas by three out of four of the F(ab')<sub>2</sub> tests (Table 2). Over twice as many samples tested positive in the F(ab')<sub>2</sub> test that used BSBMV-den antiserum than did by western blot. Results from only four out of nine ELISAs fell within 20 percentage points of western results.

Results vary among tests, and, currently, no clear trend has emerged as to which ELISA or antiserum detects greater or fewer numbers of positive samples.

## **CROSS-PROTECTION BETWEEN BEET SOILBORNE MOSAIC VIRUS AND BEET NECROTIC YELLOW VEIN VIRUS**

Cross-protection is a phenomenon whereby prior infection with one (protecting) plant virus prevents or interferes with superinfection by another closely related virus (challenge). In Texas, a new virus in sugar beet was identified as being morphologically similar to BNYVV but serologically distinct. This virus was characterized and named beet soilborne mosaic virus (BSBMV). In the past five years we have collected different isolates of BSBMV. Based on the studies made by Heidel et al., BSBMV causes mild damage to sugar beets as compared to BNYVV. Due to similarities with BNYVV, BSBMV was thought to be a good candidate for cross-protection of BNYVV. The objective of this study was to study the effectiveness of BSBMV to cross-protect BNYVV under green house conditions. In this study we used a novel technique for mechanical inoculation of protecting and challenging virus.

### **GREENHOUSE STUDY**

Inoculation Method of Cross-Protection and Cross-Protection Experiment. Uniform 10-14-day old seedlings grown in sand, was doubly inoculated with BNYVV and BSBMV, simultaneously or at intervals; of 2, 5, 10, and 15 days, by the vortexing method. Positive controls for each experiment were similar groups of plants inoculated singly with either challenge BNYVV or protecting BSBMV virus at the time corresponding to that at which doubly inoculated plants were inoculated. Healthy plants, which had been mock inoculated with buffer, were also used as negative controls. After vortexing plants were replanted individually in the soil and were randomly arranged and maintained in the greenhouse at 22-25 C with a normal day light conditions. Five doubly inoculated plants and control sets were taken randomly in each sampling at various times after the challenge inoculations. Samples were individually tested by ELISA.

### **RESULTS AND CONCLUSIONS**

The results obtained from virus detection by ELISA showed a high degree of cross-protection between BNYVV and BSBMV-EA. This cross-protection was also effective when reciprocal combination of challenge and protecting virus was used, ie. BNYVV was the protecting virus and BSBMV the challenge virus. In some of the protected plants, the cross-protection was overcome and the protected tested positive for challenge virus (Table 1).

Our results indicated that the effectiveness of cross-protection increased with the increase in inoculation interval between protecting and challenge virus. Plants started to show cross-protection phenomenon within 10 days after the challenge inoculation when the inoculation interval was 5 days or more. For example, 10 days after BNYVV challenge inoculation, challenge virus detected in 80% plants when the inoculation interval was 2 days. On the other hand, 30 days after BNYVV challenge inoculation, the challenge virus was detected in 50% plants when the inoculation interval was 2 days. When BNYVV and BSBMV-EA were inoculated simultaneously there was no cross-protection even after 30 days when the virus was inoculated. There were some signs of cross-protection of challenge virus when the inoculation interval was 2 days, but it was not consistent.

Our results indicate that cross-protection is effective and potentially could be used to control Rhizomania. The next challenge is to find methods to make us of this phenomenon in the field.

**Table 1.** Effects of interval between BSBMV-EA (protecting) and BNYVV (challenge) virus inoculation on the persistence of cross-protection.

Inoculation <sup>b</sup> interval	Virus tested	Virus detection frequency (and D/S ratio) <sup>c</sup> after			
		10 days <sup>a</sup>	15 days	20 days	30 days
		Shoot	Shoot	Shoot	Shoot
0	BSBMV-EA	0.8 (0.9)	0.8 (1.0)	1.0 (1.0)	1.0 (1.0)
	BNYVV	0.8 (0.9)	0.8 (0.7)	1.0 (1.0)	1.0 (1.0)
2	BSBMV-EA	1.0 (1.0)	0.8 (1.0)	1.0 (1.0)	0.8 (1.0)
	BNYVV	0.8 (0.7)	0.2 (0.3)	0 (0.1)	0.5 (0.4)
5	BSBMV-EA	0.8 (1.0)	1.0 (1.0)	0.8 (1.0)	1.0 (1.0)
	BNYVV	0.2 (0.4)	0 (0)	0 (0)	0 (0)
10	BSBMV-EA	0.8 (1.0)	0.8 (1.0)	0.8 (1.0)	0.8 (1.0)
	BNYVV	0 (0)	0.2 (0.2)	0 (0)	0.2 (0.2)
15	BSBMV-EA	1.0 (1.0)	1.0 (1.0)	0.8 (0.8)	1.0 (1.0)
	BNYVV	0.3 (0.3)	0.2 (0.4)	0.4 (0.4)	0.2 (0.2)

<sup>a</sup>Days after challenge inoculation. Samples were tested by ELISA.

<sup>b</sup>Interval in days between protecting (BSBMV-EA) and challenge (BNYVV) inoculations.

<sup>c</sup>[Mean ELISA value for doubly infected plants - Mean ELISA value for healthy plants/ mean ELISA value for singly infected plants - mean ELISA value for healthy plants]

# EFFECT OF SOIL MOISTURE ON RHIZOMANIA

(BSDF Project 507)

Water is the most important compound in an active plant. It constitutes more than 80% of the growing tissue and is essential for plant growth, metabolism, physiology and morphology. These functions are all affected by the amount of water a plant receives during the growing season, and the time and method of water application. In the United States, about one-third of all potentially arable land suffers from inadequate water supply, which directly impacts crop productivity. This is especially true in the western United States where high wind velocities and intensive solar radiation often accelerate evapotranspiration beyond the plants capacity to keep up. The inability of a plant's root system to supply such demands is one of the principal reasons crop plants rarely attain their full genetic potential for yield. On a worldwide basis, yield losses due to water deficit exceed those from all other causes combined.

In an attempt to maximize production, farmers often over irrigate, which contrary to desired results, can lead to problems with soilborne diseases. Some diseases caused by soilborne pathogens are reduced by increased levels of irrigation, however, most diseases are increased.

There is no question that farmers need to devote more attention to better integration of disease and irrigation management strategies, with this in mind the primary goal of this research was to determine the economic threshold for irrigation of crops growing in pathogen infested soils. The economic threshold for irrigation is defined as the amount of water necessary to produce an economically profitable yield while keeping disease losses to a minimum. Irrigation applications above the threshold result in unacceptable yield loss to disease, while irrigation applications below the threshold are inadequate to produce an economically acceptable crop

## MATERIALS AND METHODS

An experiment was conducted at the Texas Agricultural Experiment Station in Bushland, in order to quantify the effects of different irrigation frequencies on sugar beet yield under disease pressure. Four furrow irrigation regimes (every two, three, four and five weeks) and four inoculation treatments (BNYVV, BSBMV, BNYVV+BSBMV and non-inoculated control) were arranged in a split-plot design replicated four times. Seed were coated with viruliferous sugar beet root tissue using Methyl cellulose, ground dried lateral root tissue and sugar beet seeds at a ratio of 1:1.5:10 (volume, weight, weight).

TX18, sugar beet seed were planted at a rate of 7 seed per foot. Plots were 2 rows wide and 50' long. Two border rows were planted on either side of each replication to minimize border effects. Soil moisture was monitored weekly throughout the growing season to evaluate differences in soil moisture among the described irrigation treatments.

Crop growth was evaluated twice at mid-season and harvest. One-meter rows were sampled and fresh top weight, dry top weight, and root fresh weight were determined. Disease incidence and % sucrose were evaluated at harvest on 10' plots and yield and sucrose content were evaluated

on the entire 25' – two rows plot. Disease ratings were made on a scale 0-4, with 0 equal to no disease and 4 equal to severely stunted sugar beets with heavy rhizomania type symptoms.

## RESULTS AND DISCUSSION

Limited irrigation had a positive effect in controlling disease and improving yield. The treatment irrigated every four weeks had the lowest disease incidence and the highest yield, significantly different from the other treatments. Also, sucrose content was significantly higher in the four-week irrigation treatment than in treatments irrigated every two or three weeks. Sugar beets irrigated every 5 weeks also had high percent sucrose, however, this was attributed to low irrigation levels that led to high sucrose content but low yields (Table 1). Plots inoculated with BNYVV had a significantly higher disease incidence than those in BSBMV and BNYVV+BSBMV treatments. Although plots inoculated with BNYVV+BSBMV had a significantly higher disease index than that in the control treatment, the disease index of this treatment, when compared to that of BNYVV alone, shows a possible biocontrol effect of BSBMV on BNYVV. Such a trend can also be seen in root and sucrose yields. Beets in the BNYVV+BSBMV treatment had a significantly higher yield and percent sucrose than beets in the BNYVV treatment (Table 2).

In conclusion, under conditions of this study, irrigation every four weeks was the threshold irrigation required to achieve profitable yields in pathogen-infested soils while conserving often costly irrigation water.



**Table 1:** Effect of irrigation treatment on sugar beet yield parameters.

Treatment <sup>a</sup>	No. of beets <sup>b</sup>	Disease index <sup>c</sup>	Root yield lb./plot	% Sugar
2 week	33.12 A <sup>d</sup>	0.83 A	108.50 B	13.04 B
3 week	29.75 A	1.00 A	114.59 B	12.86 B
4 week	33.31 A	0.43 B	157.19 A	13.61 A
5 week	31.31 A	0.54 B	115.00 B	13.89 A

<sup>a</sup> Plots were irrigated to field capacity at 2, 3, 4 and 5 week intervals.

<sup>b</sup> Number of sugar beets per one-meter sampled area.

<sup>c</sup> Disease ratings on a 0-4 scale. 0 = no disease, 4 = severely stunted sugar beet with heavy bearding.

<sup>d</sup> Means followed by the same upper case letter within a column are not significantly different.

**Table 2:** Effect of inoculation treatment on sugar beet yield parameters.

TREATMENT	No. of beets <sup>a</sup>	Disease index <sup>b</sup>	Root yield lb./plot	% Sugar
Control	33.50 A	0.34 C	140.38 A	13.71 A
BNYVV+ BSBMV	31.37 A	0.62 B	111.50 B	13.33 B
BSBMV	31.68 A	0.61 B	137.38 A	13.36 B
BNYVV	30.93 A	1.10 A	102.03 C	13.01 C

<sup>a</sup> Number of sugar beets per one-meter sampled area.

<sup>b</sup> Disease ratings on a 0-4 scale. 0 = no disease, 4 = severely stunted sugar beet with heavy bearding.

<sup>c</sup> Means followed by the same upper case letter within a column are not significantly different.



# **SUGARBEET RESEARCH**

## **1997 Report**

### **Section G**

Molecular Plant Pathology Laboratory  
Agricultural Research Service  
United States Department of Agriculture  
Beltsville, Maryland

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- Smigocki, A.C. and L.D. Owens. Regulation of morphogenesis by bacterial auxin and cytokinin biosynthesis transgenes. In: Morphogenesis in Plant Tissue Culture. Ed.: Soh, W.Y. and S.S. Bhojwani, in press.
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- Smigocki, A. 1997. Engineering sugarbeets for improved defense mechanisms and carbon partitioning, Proc. 29th Biennial Meeting of American Society of Sugar Beet Technologists, March 2-5, 1997, p. 254.
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## **Selected abstracts of papers published or approved for publication:**

Ann C. Smigocki. 1997. Engineering sugarbeet for improved defense mechanisms and carbon partitioning. Proc. 29th Biennial Meeting of American Society of Sugar Beet Technologists, March 2-5, p. 254.

Novel molecular genetic approaches are being utilized to enhance defense properties and improve carbon partitioning in sugarbeet. Two approaches are being used to enhance disease resistance, one of them targets pathogenic fungi and bacteria and the other insect pests. For microbial control, genes coding for proteins with defense properties are being utilized (L.D. Owens, USDA, ARS, Plant Molecular Biology Laboratory, Beltsville). These include the small, cysteine-rich proteins that have been shown in other transgenic plants to display varying levels of toxicity to a broad range of plant pathogenic fungi and to some bacterial pathogens. The cecropin MB39, DB4 thionin, osmotin and PR-S (pathogenesis related protein-S, an osmotin-like protein secreted extracellularly in contrast to the vacuole-targeted osmotin) genes were reconstructed to allow expression in different tissues and under specific inducing conditions. Transgenic sugarbeet plants carrying one to two of these genes have been regenerated and are being grown to maturity for seed production and testing for resistance to *Erwinia carotovora* subsp. *betavascularum*, *Cercospora beticola* and *Rhizoctonia solani*. For control of insect pests, a novel approach utilizing a gene (*isopentenyl transferase, ipt*) involved in the synthesis of a major class of plant regulating substances, the cytokinins, is being used. The gene was engineered to allow for induction of its expression upon insect feeding or mechanical wounding or to be expressed specifically in the sugarbeet taproot. Using this approach, enhanced resistance to tomato hornworm and a virus-transmitting pest, the green peach aphid, was demonstrated in other transgenic plants. A cytokinin-induced secondary metabolite(s) that appears responsible for the observed enhanced tolerance has been partially purified from transgenic leaves. The compound(s) appears to specifically target certain orders of insects (Lepidoptera, Homoptera, Diptera) but not others (Coleoptera). The most devastating dipteran pest of sugarbeets that feeds along the surface of tap and feeder roots is the root maggot (*Tetanops myopaeformis*). Exposure of gnotobiotic first instar root maggot larvae to the cytokinin-induced insecticidal compound(s) induced a highly atypical wild thrashing and twitching behavior that although reduced was still noted after 4 days of incubation (C.A. Wozniak, USDA, ARS, Northern Crop Science Laboratory, Fargo, ND). A cytokinin biosynthesis gene reconstructed for taproot-specific expression was introduced into sugarbeet for *in planta* evaluation of its effect as a feeding deterrent for the root maggot. Transgenic plants and their progeny will be evaluated for enhanced tolerance to the maggot. Concomitantly, cytokinin's participation in carbon partitioning will be evaluated in these transgenic plants. Transport of assimilates towards site of cytokinin application has been demonstrated in



many plant organs but the mechanism behind this transport is not known. Local accumulation of cytokinin in sink organs such as seeds, fruits and roots is speculated to potentially increase plant productivity due to increased assimilate transport. In addition, high cytokinin levels have been correlated with cambial initiation and rapid cell division periods in developing sugarbeet taproots and prior to cytokinesis in synchronized sugarbeet cell suspension cultures derived from the taproot. These results suggest that higher cytokinin levels in the taproot may lead to increased cell division, additional vascular rings and higher sucrose yield. High auxin concentrations were required to stimulate rooting of transgenic shoots carrying the cytokinin gene fused to the taproot-specific promoter presumably to compensate for the elevated cytokinin levels. Rooted transformed plants either appeared normal or exhibited varying degrees of cytokinin effects such as more adventitious shoot development, reduced apical dominance and dark green leaves. Further analysis of transgenic plants for levels expression of the cytokinin gene and genes for sucrose-metabolizing enzymes and sucrose transporters will help correlate the effect of cytokinin on sucrose accumulation and storage root structure and shape. Increased cell division and number of vascular rings in the taproot is anticipated not only to increase the sugar content but also lead to a low-tare sugarbeet with globe-shaped storage root with fewer branches or grooves that would be of benefit to farmers, processing plants and the environment.

Smigocki, A.C., Snyder, G.W., McCanna, I. and L.D. Owens. 1997. Transgenic sugarbeets engineered for production of high cytokinin levels in the taproot. Proc. 29th Biennial Meeting of American Society of Sugar Beet Technologists, March 2-5, p. 225.

Cambial initiation and rapid cell division periods in the developing sugarbeet taproot have reportedly been correlated with increased cytokinin levels. To evaluate the effect of increased endogenous cytokinin concentrations on vascular ring development and assimilate transport to the taproot, a bacterial cytokinin biosynthesis gene (*ipt*) was introduced into sugarbeets. To target expression of the *ipt* gene to the taproot, it was fused with a tuber-specific promoter from the patatin gene of potato. Particle bombardment was used to introduce the reconstructed *ipt* and a kanamycin-selectable marker gene into embryogenic hypocotyl callus. Shoots regenerated on kanamycin-containing medium required high auxin concentrations (3 mg IBA and 2 mg NAA per liter) for root initiation, presumably to compensate for the elevated cytokinin levels. One rooted transformant appeared normal except for a slight increase in adventitious shoot development. Another transformant was more difficult to root and exhibited other characteristic cytokinin effects, namely reduced apical dominance and dark green leaves. Southern blots of PCR products digested with various restriction enzymes confirmed the presence of the *ipt* and NPTII genes in these two transformants. Transgenic plants are being further analyzed for expression of the cytokinin gene and sucrose content.

Smigocki, A.C., McCanna, I., Ivic, S., Snyder, G.W., Sicher, R.C. and L.D. Owens. 1997. Effects of cytokinin overproduction on sucrose concentrations and sugarbeet taproot morphology. The Quadrennial Joint Annual Meetings of the American Society of Plant Physiologists, August 2-6, Plant Physiol. Supplement, Vol. 114 (3):303.

Transport of assimilates towards site of cytokinin application has been demonstrated in many plant organs. In the developing sugarbeet taproots increased cytokinin levels have been correlated with cambial initiation and rapid cell division periods. To increase endogenous cytokinin concentrations in the sugarbeet taproot, we fused a bacterial cytokinin biosynthesis gene (*ipt*) with a tuber-specific promoter from the patatin gene of potato. Agrobacterium-mediated gene transfer was used to introduce the reconstructed *ipt* and a kanamycin-selectable marker gene into cultured sugarbeet cotyledons. Shoots that regenerated on kanamycin-containing medium were difficult to root. To compensate for the presumably elevated cytokinin levels, transformants were cultured on media with high auxin concentrations (3 mg IBA and 2 mg NAA per liter). One rooted transformant appeared normal except for a slight increase in adventitious shoot development. Another transformant that was more difficult to root and exhibited other characteristic cytokinin effects, namely reduced apical dominance and dark green leaves. Genomic Southern blot analysis confirmed the presence of the *ipt* and NPTII genes in these two transformants. Transgenic plants are being analyzed for expression of the cytokinin gene and carbohydrate content.

Snyder, G.W., Ingersoll, J.C., Smigocki, A.C. and L.D. Owens. Transformation of sugarbeet (*Beta vulgaris* L.) with novel pathogen defense genes using particle bombardment or Agrobacterium. Plant Cell Reports, in press.

Two methods for sugarbeet transformation have been developed; one uses Agrobacterium cocultivation with seedling cotyledons and the other DNA-coated-particle bombardment of embryogenic callus. Transformation efficiencies were about 1% and 8% for the Agrobacterium and bombardment methods, respectively. Transgenic sugarbeets were produced carrying genes encoding pathogen-defense related proteins under transcriptional control of stress or wound-inducible promoters and a cytokinin biosynthesis gene fused to a potato patatin promoter. Analysis of a plant expressing beta-glucuronidase (GUS) under the control of the tobacco osmotin promoter showed that expression was wound-inducible with detectable activity at 8 h and maximal activity at 96 h post-wounding.

Snyder, G.W., Ingersoll, J.C. and L.D. Owens. 1997. Genetic transformation of sugarbeet using particle bombardment and novel plant pathogen defense genes. Proc. 29th Biennial Meeting of the American Soc. Sugar Beet Technologists, 224.

Several transgenic sugarbeets have been produced each containing genes encoding pathogen-defense related proteins under transcriptional control of stress or wound inducible promoters. Promoters used in this study included the CaMV 35S, and those derived from genes encoding osmotin and pathogenesis related protein-S (PR-S) from tobacco, and proteinase inhibitor II (Pin II) from potato. The promoters were cloned 5' to cDNA's encoding either beta-glucuronidase (GUS), osmotin, PR-S, barley leaf thionin, or cecropin. A sugarbeet transformation method has been developed using embryogenic callus generated from seedling hypocotyls. To date plants have been recovered which carry the following chimeric genes: 35S-GUS, osmotin-GUS, osmotin-osmotin, osmotin-cecropin, PinII-thionin, PinII-cecropin, PrS-thionin, osmotin-osmotin/oxmotin-cecropin. GUS activity in the osmotin-GUS plant while in tissue culture was found to be constitutive with expression 10 times the level found in the 35S-GUS plant with no wound induction. When the plant was transferred into soil, the constitutive level of GUS expression in the leaf was found to be very low. However, GUS activity was inducible by wounding of an excised leaf, with activity peaking at about 48 hours. Most of the plants have been transferred to soil and are being tested for their response to infection by known sugarbeet pathogens.

# **Gene Transfer to Optimize the Sucrose Storage Capacity of the Sugarbeet Taproot**

*BSDF Project 810*

**Ann C. Smigocki**

Selective breeding and improved agricultural practices have increased the fresh weight concentration of sucrose in the sugarbeet taproot to around 18% and the dry weight concentration of sucrose to around 75%. The true root and the hypocotyl both contribute to the storage organ that is composed of cambial rings. The rings begin to form early in development and by two weeks after emergence the primary cambium is complete. By the eighth week, 8 rings are produced and at that point ring initiation slows. Maximum number of rings observed at harvest is 12 to 15. Significant expansion of the taproot involves the two innermost rings while rings 3 to 8 show progressively less activity. Rings 9 and above make almost no contribution to the expansion of the storage root and cambial activity is greatest only in the portion of the root with the largest diameter. The ring structure of the mature root is due to alternating vascular and parenchymatous zones that arise by division, enlargement and differentiation of the cambial derivatives. Sucrose is unloaded from the phloem and is stored in the vacuoles of parenchyma cells in both zones but preferentially in the vascular zone. A number of studies have concluded that in order to optimize the sucrose storage capacity of the sugarbeet taproot its structure would have to be modified to contain more vascular zones with shorter distances between the phloem and the storage vacuoles.

Changes in phytohormone profiles of sugarbeet taproots between sowing and harvest have been determined and related to 1) initiation of cambia, 2) cell division of the cambia and 3) rapid cell expansion stages in root development. During the period of cambial initiation (0-1 g root dry mass) levels of three phytohormones including cytokinins were high but declined sharply at the end of this developmental period and during rapid cell expansion. The levels of auxin, cytokinin and ABA increased again just prior to maximum cell division (20-60 g root dry mass). It is well

established that cytokinins induce cell division and in taproot-derived sugarbeet suspension cultures, cytokinin levels were shown to peak just prior to cytokinesis. These results suggest that higher cytokinin levels in the taproot will lead to increased cell division, additional vascular rings and increased sucrose yield.

Since field applications of phytohormones are of limited value due to high costs and rapid degradation, we have genetically engineered sugarbeets for production of high cytokinin levels in the taproot. In other studies, we have varied cytokinin concentrations *in planta* using a bacterial cytokinin biosynthesis gene (*ipt*). To increase endogenous cytokinins in the taproot, the *ipt* gene was fused to a tuber-specific promoter from the patatin gene of potato and introduced into sugarbeet using an *Agrobacterium*-mediated cotyledon transformation method or particle bombardment of embryogenic hypocotyl callus. Three shoots were regenerated on selective media. Molecular analyses by PCR, Southern and Northern blots confirmed the presence of the *ipt* and a selectable marker gene in all three transformants. To compensate for the presumably elevated cytokinin levels, exposure of shoots to high auxin concentrations (50 mg IBA/ml) for a 24 hour period was required to stimulate rooting of two of the transformants. The *ipt* shoots rooted in 4-8 weeks in comparison to 2 weeks for the controls (3 mg IBA/ml). One of the transformants appeared normal except for increased adventitious shoot development and another exhibited dark green leaves, reduced apical dominance, and leaf epinasty, all typical cytokinin effects. Preliminary analysis revealed an approximate 3 fold increase in sucrose levels in the dark green leaves. Taproot and leaf cytokinin levels were also higher by about 2- and 20-fold, respectively, in comparison to those in normal plants. We are currently crossing transgenic plants with sugarbeet breeding lines for seed production and are experimenting with a fairly new sugarbeet transformation method utilizing guard cell protoplasts to obtain at least five to ten more independently transformed plants for analysis.

Higher endogenous cytokinin levels in these transgenic plants are anticipated to increase the sink activity of the taproot leading to an increase in the overall root productivity and a decrease in the leaf sucrose storage pools. The removal of more sucrose at the source may also decrease the

feedback inhibition on the system and might be expected to increase the maximum rate of photosynthesis. Additionally, increasing cell division and the number of vascular rings in the taproot is expected to produce a low-tare sugarbeet with globe-shaped storage root with fewer branches or grooves. A low-tare sugarbeet would be of great benefit to the farmers, processing plants and the environment.











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